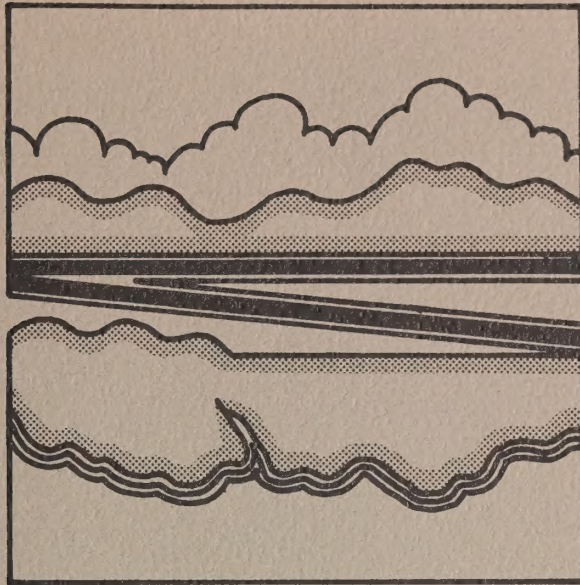


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INSTITUTE OF GOVERNMENTAL  
STUDIES

JUN 11 1976

UNIVERSITY OF CALIFORNIA

*City planning Fremont  
Emergency Relief " "  
" " Earthquake*

# FREMONT GENERAL PLAN SEISMIC SAFETY & SAFETY ELEMENTS



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D. R. NICHOLS, UNITED STATES GEOLOGICAL SURVEY

RESOLUTION NO. 3669

RESOLUTION OF THE CITY COUNCIL OF THE CITY OF FREMONT AMENDING THE GENERAL PLAN OF THE CITY OF FREMONT BY THE ADOPTION OF A SEISMIC SAFETY AND SAFETY ELEMENT, AND BY THE AMENDMENT OF THE GENERAL PLAN POLICY TEXT TO SET FORTH THE GOALS, OBJECTIVES, PRINCIPLES AND ACTION PROGRAM FOR SAID SEISMIC SAFETY AND SAFETY ELEMENT.

---

WHEREAS, pursuant to Sections 65302(f) and 65302.1 of the Government Code of the State of California it is required that each city adopt a Seismic Safety and Safety Element; and

WHEREAS, there has been prepared a proposal (GPA-71-13) to amend the General Plan of the City of Fremont through adoption of a certain document entitled "Seismic Safety and Safety Elements of the General Plan" as shown and set forth in Exhibit "A" attached hereto and made a part hereof; and

WHEREAS, there has also been proposed in connection therewith a certain Policy Text amendment to the General Plan, Policy Text, consisting of Goals, Objectives, Principles, and Action Program of the Seismic Safety and Safety Elements of the General Plan, as shown and set forth in Exhibit "B" attached hereto and made a part hereof; and

WHEREAS, the Planning Commission, pursuant to law, has held a public hearing on said proposed amendment to the General Plan and to the General Plan, Policy Text, and did certify its recommendations and findings thereupon to the City Council; and

WHEREAS, the City Council, pursuant to law, has held a public hearing on the proposed amendment to the General Plan and to the General Plan, Policy Text, and did consider said proposed amendments, recommendations, and findings of the Commission;

NOW, THEREFORE BE IT RESOLVED, that the City Council of the City of Fremont does hereby adopt the said proposals as set forth above and in Exhibits "A" and "B" as amendments



to the General Plan and amendments to the Policy Text of the General Plan, said document and Policy Text including maps and appendices included therewith to be officially designated as the Seismic Safety and Safety Elements of the General Plan. of the City of Fremont, pursuant to Sections 65302(f) and 65302.1 of the Government Code of the State of California;

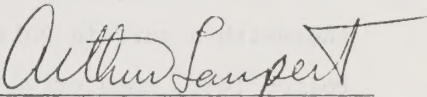
BE IT FURTHER RESOLVED, that the Fremont General Plan, Policy Text shall be amended in particular by the addition of Item "J" to Section III. City Wide Policies; said item to be entitled "Seismic Safety and Safety Elements" and to contain the text of said Goals, Objectives, Principles, and Action Program as set forth in said Exhibit "B".

ADOPTED June 3, 1975 by the City Council of the City of Fremont, by the following vote, to wit:

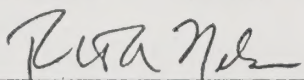
AYES: Councilmen Dillon, Lampert, Mezzetti, Steel

NOES: None

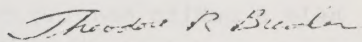
ABSENT: Councilman Rhodes

  
\_\_\_\_\_  
Mayor Pro Tempore

ATTEST:

  
\_\_\_\_\_  
City Clerk

APPROVED AS TO FORM:

  
\_\_\_\_\_  
Assistant City Attorney



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## **GOAL, OBJECTIVES, PRINCIPLES AND ACTION PROGRAM**

### **A. CITY WIDE GOAL**

To provide for the continuing development of a safe community based on adequate information about geologic conditions and potential hazards in the physical environment.

### **B. OBJECTIVES**

1. To reduce the risks of loss of life, human injury, economic loss and disruption of the community resulting from earthquakes, floods, major fires, or other major disasters.
2. To assure the continued functioning of essential public facilities and services during and after a disaster.
3. To assure that future development in the City is located and designed to minimize the damages and hazards caused by disasters.
4. To create public understanding of physical hazards and to inform the public of actions that families, business organizations, and others may take to reduce risks and losses in the event of a natural disaster.
5. To provide for safe emergency facilities in proportion to possible needs and to identify and maintain safe access and evacuation routes in the event of a damaging earthquake or other major disaster.

### **C. PRINCIPLES**

1. The Seismic Safety and Safety Elements of the General Plan provide general information about possible physical hazards which should be used as a guide to safe development and reduction of potential risks.
2. Ground rupture along a fault trace and landsliding are two of the most serious physical threats to life and property which may accompany an earthquake. These hazards can be avoided by proper siting and grading, based on studies of the development site, and by removing any buildings which are hazardous to life because of their location on fault traces or in the path of landslides.
3. Massive inundation caused by a dam failure is a third major physical hazard which can threaten the Fremont area. Much of the inhabited area of the city would be inundated by waters released by a dam failure. Because of the low probability of such an occurrence, however, evacuation in the event of a dam failure, rather than permanent removal of existing uses, is the most realistic means of reducing this risk.
4. Hazards related to ground shaking and soil liquefaction can be mitigated through adequate site analysis, proper siting, building design and construction, and through remedial measures to reinforce or eliminate weak or hazardous building components.

5. Continued availability of essential utilities and services is one of the most important factors for minimizing economic and social disruption following an earthquake or other major disaster.
6. Adequate precautions should be taken to insure that utility systems and service facilities do not create additional hazards as a result of a disaster. Such hazards could include:
  - a. Fires resulting from broken electric connections and ruptured gas lines.
  - b. Loss of water pressure needed for fire fighting.
  - c. Contamination of the water supply by leakage from broken sewers.
  - d. Structural and equipment damage at the hospital.
7. A given level of fire protection is provided to protect citizens and their property. Those properties or processes which constitute a potentially higher risk or demand upon the Fire Protection System should be required to provide supplemental mitigating measures.
8. The public should be able to obtain adequate information to enable them to protect their lives and property from physical hazards and to take appropriate actions to reduce risks within the home, business, or other place of work.

#### **D. ACTIONS**

The following actions are listed in order of priority for accomplishment.

##### **1. Land Development Actions**

| <u>Priority</u> | <u>Action</u>                                                                                                                                                                                                                                                             |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A               | Amend the Fremont Municipal Code to require geologic studies for land development or building construction in areas of potential geologic hazard shown on the Geologic Hazards Map, according to the criteria included in the Seismic Safety Element of the General Plan. |

##### **2. Building Safety Recommendations**

| <u>Priority</u> | <u>Action</u>                                                                                                                                                                                                                                                                                                                                             |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A               | Adopt revised editions of the Uniform Building Code as rapidly as possible following their publication.                                                                                                                                                                                                                                                   |
| B               | Prepare and adopt an ordinance giving the Chief Building Official the power to require a seismic analysis and geologic report to determine if a building is a life hazard in an earthquake, and giving him the authority to declare such building to be an unsafe building and therefore subject to abatement under the Uniform Building Code (Sec. 203). |



- C Initiate a program to enforce the hazardous building appendages section of the 1973 Uniform Building Code.
- C Conduct a structural and access evaluation of all buildings of the following types:
  - Public buildings (except permanent public school buildings)
  - High occupancy buildings (except hospitals)
  - Buildings constructed prior to 1940, other than single-family residences and accessory buildings.
- C Prepare and adopt an ordinance specifying standards for the design and installation of equipment and furnishings for emergency service structures, to avoid interruption of vital services and functions and to reduce hazards to building occupants.

### 3. Utility Systems

#### Priority

#### Action

- A Request that utilities evaluate the ability of present installations to withstand physical hazards and report to the City on findings, corrective measures needed and a timetable for carrying out any necessary modifications.
- A Establish a Seismic Safety Review Committee made up of representatives of utilities and pipeline systems to establish standards for utility construction across fault traces and areas of unstable ground and to review designs for new or modified facilities proposed for such locations.
- A Where necessary, obtain a duplicate set of utility records and any data needed for the continuing operation and repair of vital utility services in the event of a disaster. These records would be retained in the Emergency Operations Center and updated regularly.

### 4. Emergency Response Plan Program

#### Priority

#### Action

- A Continue to upgrade the City's Emergency Response Plan and improve the City's ability to respond to a disaster with adequately trained and equipped personnel.
- A Evaluate the ability of all components of the emergency communications system to withstand earthquake shaking and ground rupture.

- |   |                                                                                                                                                    |
|---|----------------------------------------------------------------------------------------------------------------------------------------------------|
| B | Study the feasibility of developing a Volunteer Disaster Response program.                                                                         |
| B | Continue to work with the Fremont Unified School District and other to establish temporary assembly facilities for persons displaced by disasters. |
| B | Schedule regular earthquake disaster drills, to test the emergency service plan and train personnel in its use.                                    |
| C | Work with the Red Cross to prepare a family reunification program to be used in the event of a disaster.                                           |

## 5. Public Information and Safety Actions

### Priority

### Action

- |   |                                                                                 |
|---|---------------------------------------------------------------------------------|
| B | Obtain and distribute information materials that:                               |
|   | Provide information about seismic hazards.                                      |
|   | Describe ways to avoid or minimize damage.                                      |
|   | Describe ways to avoid injury and reduce damage during and after an earthquake. |

## 6. Updating and Expanding Geo-Seismic and Safety Hazards Information

### Priority

### Action

- |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A | Establish a file available to the public and other agencies for all pertinent geo-seismic information acquired by the City. A duplicate file should be placed in the Main Library.                                                                                                                                                                                                                                                             |
| B | Establish a reporting system for all geo-seismic information based on seismic events, field observation or other sources, and incorporate this information in the City's Information/Data System. Include: <ul style="list-style-type: none"> <li>. earthquake shaking damage</li> <li>. ground subsidence</li> <li>. liquefaction</li> <li>. landslides</li> <li>. fault creep</li> <li>. seiches</li> <li>. other related factors</li> </ul> |

## 7. Fire Hazards Reduction

### Priority

### Action

- |   |                                                                                                                                                                                                   |
|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A | Continue to require as part of the site plan and architectural review process that all new developments provide adequate access and clearances for fire equipment and fire suppression personnel. |
|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|



- A Develop and implement a community fire protection system whose goals are: To prevent and/or limit life and property loss due to fire. This will be accomplished through the continued efforts of the Fire Department, Planning Department, Building Department, Public Services Department, and other departments making up the fire protection system. This reduction will be accomplished through code enactment, and enforcement relative to fire resistance and density of structures, through control of contents and processes within structures, through the development of fire safety attitudes and maintenance of an adequate, well-trained and equipped fire suppression force.
- C Evaluate the feasibility of establishing a special assessment district for fire protection in the hills, as a means of covering the higher costs of fire fighting in these more distant areas.

## 8. Reduction of Flood Hazards

| Priority | Action                                                                                                                                                    |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| A        | Continue to require flood resistant siting and/or construction as a condition of subdivision or development approval, in areas subject to minor flooding. |
| C        | Update the evacuation program to respond to possible inundation in the event of dam failures on upper Alameda Creek and its tributaries.                  |





# SEISMIC SAFETY AND SAFETY ELEMENTS OF THE GENERAL PLAN

## I. INTRODUCTION

### A. SUMMARY

Earthquakes, fires, floods, landslides, and other natural disasters pose threats to life and property wherever they occur. The effects of these events are particularly serious in urban areas, where population is concentrated and highly dependent on man-made structures for essential services and life-support systems. This Element describes the likelihood of occurrence of earthquakes and other natural disasters in Fremont and the degrees of severity that can be anticipated for each type of disaster. It then considers the hazards associated with each type of disaster, evaluates the implications of possible hazards for land use and public facility planning, and sets forth goals and objectives for the reduction of hazards through land use plans and regulations. Finally, the Element recommends specific actions to prevent or alleviate hazardous conditions and reduce the risks to life and property resulting from natural disasters.

### B. LEGAL BASIS FOR SEISMIC SAFETY AND SAFETY ELEMENTS

In 1972, the State of California adopted legislation requiring each city and county to prepare a Seismic Safety Element as a component of its General Plan. The Seismic Safety Element is to consist of:

"An identification and appraisal of seismic hazards, such as, susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to the effects of seismically induced waves, such as, tsunamis and seiches."

"The Seismic Safety Element shall also include an appraisal of mudslides, landslides, and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards, such as, possible surface ruptures from faulting, to ground shaking . . ." Government Code, Section 65302(f).

The basic objective of the Seismic Safety Element is to reduce loss of life, injuries, damage to property, and economic and social dislocations resulting from future earthquakes.

In addition to the Seismic Safety Element, local governments are required to include a Safety Element in their General Plans. The Safety Element is closely related to the Seismic Safety Element, since it is concerned with reducing hazards imposed by natural disasters, primarily fires and floods. These hazards may, in fact, accompany an earthquake. Fire caused the majority of damage and life loss associated with the 1906 San Francisco earthquake; massive flooding from dam failures nearly occurred after the 1971 San Fernando earthquake.<sup>1</sup> Similarly, dam failures are a potential danger in Niles Canyon. The Safety Element is also closely related to the City's Emergency Plan, for which the Police Department is the lead agency. Subjects to be included in the Safety Element are:

- “ . evacuation routes
- . peak load water supply requirements
- . minimum road widths
- . clearances around structures
- . geologic hazard mapping”
- . . . Government Code Section 65302.1

Because the Seismic Safety and the Safety Elements are complementary planning programs for dealing with natural disasters, they are combined in this report. This procedure is consistent with recommendations of the State Council on Intergovernmental Relations.



## **II. FREMONT'S ENVIRONMENTAL SETTING: IMPLICATIONS FOR NATURAL DISASTER PLANNING**

### **A. GENERALIZED GEOLOGY OF FREMONT**

Underlying the City of Fremont is a deep bedrock trough, which rises to form the steep hills in the eastern part of the City and the Coyote Hills at the Bay margin. This trough has been filled with alluvium deposited by streams flowing from the hills and with Bay mud and other sediments. These alluvial materials are found as deep as 400-600 feet in some areas. In several past geologic eras, the flat plain lying between the hills and Bay may have been a fresh water lake, accumulating fine sediments and organic matter on its bed. At other times, including the present, the plain has been crossed by meandering streams which deposit gravel and silt as they flow toward the Bay. The beds of these streams are found at frequent intervals in the subsurface soil deposits forming pockets of unconsolidated material within the more dense, cohesive soils.

Moving from east to west, the subsurface materials include progressively more clay and silt and less sand and gravel. In most areas, these materials are somewhat mixed, due to the wandering pattern of stream beds. Ground water, another important engineering geologic factor, is relatively high east of the Hayward fault, due to the impervious barrier formed by the pulverized materials of the fault zone. West of the fault, the water level is substantially lower, rising again near the Bay. A more complete description of the geologic structure is found in the report by Woodward-Clyde Consultants, "Geotechnical Input, Seismic Safety Element, Fremont, California, April, 1975."

### **B. SEISMIC CONDITIONS**

#### **1. Earthquake Activity**

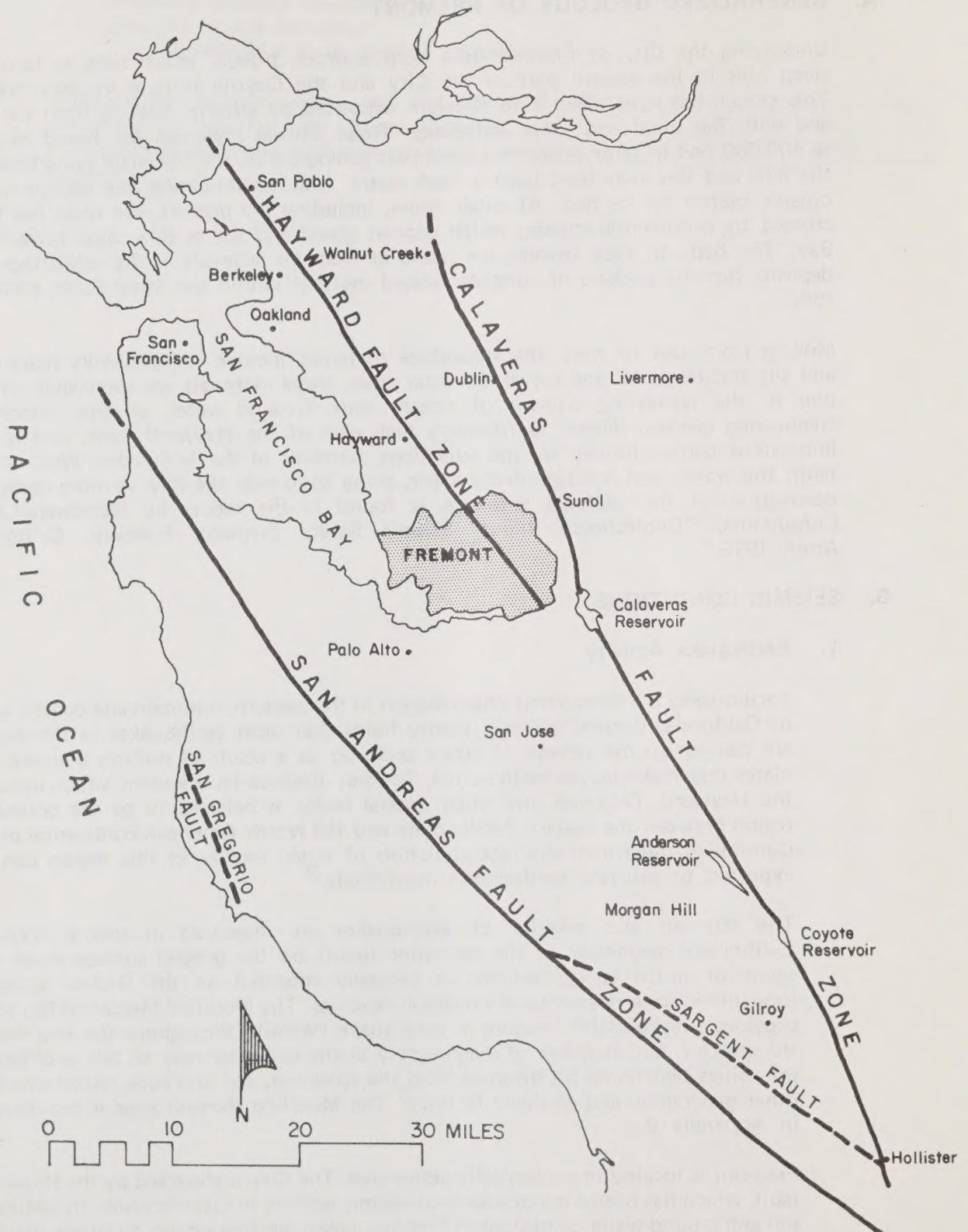
Earthquakes are a recurrent phenomenon in the western mountain and coastal areas of California. Current geologic theory holds that most earthquakes in this region are caused by the release of strain built up as a result of motion between the plates that make up the earth's crust. The San Andreas fault system, which includes the Hayward, Calaveras and other coastal faults, is believed to be the boundary region between the eastern Pacific plate and the North American continental plate. Continuing movement and accumulation of strain energy in this region can be expected to generate earthquakes indefinitely.<sup>2</sup>

The strength and severity of earthquakes are measured in several ways. Earthquake magnitude at the epicenter (point on the ground surface above the point of initial energy release) is generally recorded on the Richter scale, a logarithmic scale related to seismograph readings. The Modified Mercalli (MM) scale provides a more useful measure of earthquake intensity throughout the area where the quake is felt. A quake of magnitude 7 at the epicenter may be felt as different intensities depending on distance from the epicenter, soil and rock conditions and other geographic and geologic factors.<sup>3</sup> The Modified Mercalli scale is reproduced in Appendix B.

Fremont is located in a seismically active area. The City is traversed by the Hayward fault, which has been a major source of seismic activity in historic times. In addition, soil and ground water conditions in Fremont make the area subject to strong shaking generated by earthquakes on the San Andreas fault,<sup>4</sup> which traverses the

FIGURE I

Major Earthquake Faults in the San Francisco Bay Area





Santa Clara Valley and the San Francisco Peninsula, and the Calaveras fault, which lies to the east of Fremont in the Diablo range. No earthquake activity has been recorded for the Mission fault, which is mapped as traversing Mission San Jose and Niles east of Mission Boulevard, or the Silver Creek fault, reported to lie immediately east of the Coyote Hills.

The Fremont area has been shaken by moderate to severe earthquakes an estimated sixty times in the recorded history of the area.<sup>5</sup> Many of these earthquakes were centered on the San Andreas fault rather than the Hayward fault, but nonetheless caused damage in the East Bay.

Two major quakes generated by movement on the Hayward fault struck Fremont in the nineteenth century. Both have been assigned a Mercalli intensity of IX to X, based on the descriptions of motion and property damage made by observers.<sup>6</sup> The first occurred in June, 1836. Ground breakage was reported from Irvington to San Pablo.

The second major nineteenth century earthquake occurred in October, 1868. Ground breakage was reported from Warm Springs to San Leandro; horizontal offset of three feet was recorded in the vicinity of Stivers Lagoon (Lake Elizabeth).<sup>7</sup> The major structural damage was to brick and adobe buildings: *The History of Washington Township* states that the adobe Mission San Jose Church and a brick church and a two-story brick commercial building in Centerville were destroyed, while most brick chimneys were thrown down. The community of Alvarado (Union City) experienced considerable damage to buildings and bridges.<sup>8</sup>

While not centered on the Hayward fault, the 1906 earthquake on the San Andreas fault caused considerable damage in the Fremont area. Again, as in 1868, brick buildings were most subject to failure. Frame dwellings suffered little or no damage. Centerville and Irvington had the greatest number of brick dwellings and commercial buildings, and therefore suffered the greatest damage. Chimneys were generally destroyed. In several areas, water tanks and windmills fell when their supports failed, and the railroad tracks north of Newark were shifted slightly. Cracks opened in the earth and shallow ponds were formed. Water and sand were ejected from some of the cracks. This phenomenon typically accompanies strong shaking in fine-grained, saturated soils and is an indicator of soil liquefaction.<sup>9</sup>

The largest earthquake related to the Hayward fault in this century occurred in 1933. The quake, which had a Mercalli intensity of VIII, was centered near the mouth of Niles Canyon. The motion knocked down most of the brick chimneys in Niles and Irvington and caused rock falls which blocked Niles Canyon Road.<sup>10</sup>

Studies of the frequency and intensity of earthquakes on the major fault system of the Bay Area suggest a general pattern of recurrence. Geologists and seismologists generally agree that a major quake will occur somewhere on the San Andreas system on the average of once every 50 years, and that such a quake (magnitude 8-8.3) will occur on the Bay Area segment of the San Andreas on the average of once every 100 years.<sup>11</sup> As indicated by the report on the 1906 San Francisco earthquake, any major earthquake on the San Andreas system in the Bay Area will cause severe shaking in Fremont. The geologic consultants for the Seismic Safety Element believe that the maximum credible earthquakes on the Hayward and San Andreas faults would produce similar ground shaking intensities in the Fremont area.



The maximum credible earthquake that could be produced by the Hayward fault is believed to be an event of 7.5 magnitude on the Richter scale. Stronger quakes have occurred and may occur on the San Andreas fault; the maximum credible quake magnitude is considered to be correlated with fault length.<sup>12</sup>

The Calaveras fault branches from the San Andreas fault near Hollister and follows a somewhat more northerly course than the Hayward fault, passing through the Mount Hamilton-Diablo range. This fault has generated earthquakes felt in the Fremont area. Displacement along the Hayward fault producing pavement cracks near Fremont's Central Park was reported coincident with a small quake centered on the Calaveras fault in January, 1970. This occurrence indicates that ground distortion along fault traces as well as shaking may affect the Fremont area when earthquakes occur on the Calaveras fault.<sup>14</sup>

A review of the literature on seismic hazards in the Bay Area did not provide estimates of recurrence intervals of major earthquakes on the Hayward fault. For planning purposes, the best estimate is that a major quake can be expected to occur on one of the fault systems in the Bay Area every 60-100 years.<sup>15</sup> Two major quakes that produced surface rupture and lateral offset of the ground along the fault trace did occur on the Hayward fault in the nineteenth century, and it can therefore be assumed that similar events could take place at any time. The Calaveras fault is considered to be less active than the Hayward fault in the general vicinity of Fremont and therefore less likely to generate a major earthquake in this area.<sup>16</sup>

## **2. Creep or Gradual Movement Along a Fault**

In addition to the sharp movement along a fault that accompanies an earthquake, gradual movement or fault creep has occurred on the Hayward fault and has been studied in detail in Fremont. This movement typically takes place at the rate of a fraction of an inch annually. Creep distorts structures and facilities that lie across the fault. Railroad tracks crossing the Hayward fault in Fremont are subject to gradual, continuous bending; creep damage has also been documented in an industrial building at Union and High Streets in Irvington.<sup>17</sup> Fault creep has also caused damage to curbs and sidewalks in Hayward and to the University of California stadium in Berkeley.

## **C. GEO-SEISMIC, FIRE AND FLOOD HAZARDS IN THE FREMONT AREA**

### **1. Geo-Seismic Hazards**

See the Geologic Hazards Map (Map 1) and accompanying table (Table I) for a description of the geologic units and geo-seismic hazard areas.

#### **a. Surface Faulting**

Surface faulting is the ground rupture resulting from movement along faults during an earthquake or resulting from gradual movement (fault creep). In a moderate earthquake, fault rupture in rock at an average depth of 3-10 miles may not extend to the surface. In moderate to strong earthquakes, the surface faulting generally extends to the surface resulting in scarps, fractures,



sag ponds, and other features characteristics of faults which have had periods of activity over long periods of geological time. The presence of features characteristic of surface faulting in the Hayward fault zone indicates that the fault is active, is at the surface, and has been active for a long time. The absence of surface or subsurface expressions of fault movement above the Silver Creek fault, reported to lie immediately to the east of the Coyote Hills, indicates that this fault is deeply buried beneath the alluvium and is less active than the Hayward fault and is probably inactive.

The Geologic Hazards Zone map (Map 1) prepared for this study by Woodward-Clyde Consultants, consulting engineers and geologists, delineates the Hayward and Mission faults as zones of surface rupture hazard. Analysis of these zones indicates that they contain three different types of fault conditions. The zones are shown on the map as Areas I, II, and III.





# FREMONT GENERAL PLAN SEISMIC SAFETY AND SAFETY ELEMENTS GENERALIZED GEOLOGIC HAZARDS

## LEGEND

**Cs J<sub>L</sub>** GROUND SHAKING STUDY AREA C<sub>s</sub> AND LIQUEFACTION STUDY AREA J<sub>L</sub>. GROUND SHAKING CONSISTS OF A<sub>s</sub> THROUGH E<sub>s</sub> AND LIQUEFACTION CONSISTS OF F<sub>L</sub> THROUGH N<sub>L</sub> WITH THE EXCEPTION OF I.

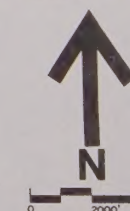
**I, II, or III** SURFACE FAULTING STUDY AREA

**X**  
**Y**  
**Z** } SLOPE STABILITY STUDY AREA

## NOTES

- 1.) FOR DESCRIPTION OF INDIVIDUAL STUDY AREA, SEE EXPLANATION TEXT PREPARED FOR EACH GEOLOGIC-SEISMIC HAZARD: GROUND SHAKING, LIQUEFACTION, SURFACE FAULTING, AND SLOPE STABILITY.
- 2.) THIS MAP DELINEATES SPECIFIC AREAS ASSESSED TO HAVE SIMILAR GEOLOGIC-SEISMIC CHARACTERISTICS DURING STRONG EARTHQUAKES, AND IS A COMPOSITE BASED ON FIVE WORKING MAPS: PRELIMINARY ENGINEERING GEOLOGY, SLOPE STABILITY SURFACE FAULTING, GROUND SHAKING, AND LIQUEFACTION.
- 3.) THIS MAP IS BASED ON AVAILABLE DATA. NO FIELD CHECKING OR FIELD STUDIES WERE CONDUCTED DURING THIS STUDY.
- 4.) THIS MAP IS NOT TO BE USED AS A SUBSTITUTE FOR SITE SPECIFIC STUDIES.

—●—●—●— FREMONT CITY BOUNDARY



## MAP 1

THIS MAP IS ONE OF SEVERAL WHICH ACCOMPANY THE TEXTUAL MATERIALS OF THE SEISMIC SAFETY AND SAFETY ELEMENTS IN THE FREMONT GENERAL PLAN. IT IS INTENDED TO ILLUSTRATE THE CONCEPTS AND PROPOSAL OF THE ELEMENT AND SHOULD BE USED FOR GENERAL PLANNING PURPOSES ONLY. PRECISE PLANNING DATA MUST BE USED TO SUPPLEMENT THIS INFORMATION AT THE TIME OF PLAN IMPLEMENTATION.

GENERALIZED GEOLOGIC-  
SEISMIC HAZARD AREAS

Project No. G-13336  
WOODWARD-CLYDE CONSULTANTS

MARCH 1975

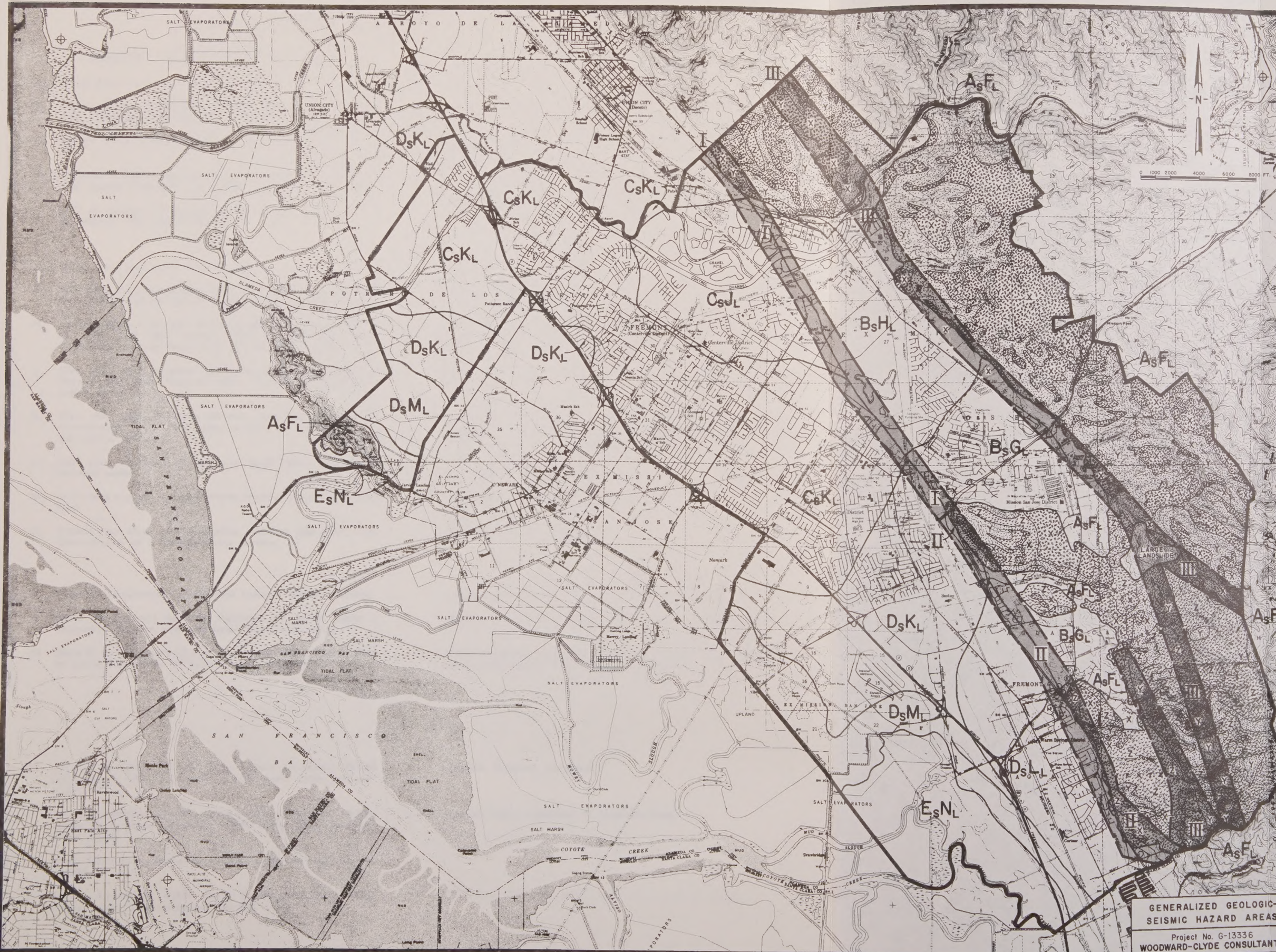








TABLE 1

## DESCRIPTION OF GEO-SEISMIC UNITS SHOWN ON GEOLOGIC HAZARDS MAP

|                  | GEOLOGY AND SITE CONDITIONS                                                                                                                                                                            | HAZARDOUS IMPACT                                                                                                                                               |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GROUND SHAKING   | A <sub>s</sub> Santa Clara and other rock formations.                                                                                                                                                  | Least severe shaking potential.                                                                                                                                |
|                  | B <sub>s</sub> Mainly dense, cohesionless soils. Depth to bedrock varies from very shallow to 200-300 feet.                                                                                            | Somewhat more severe shaking than in Area A <sub>s</sub> , affecting tall, flexible buildings.                                                                 |
|                  | C <sub>s</sub> Mainly dense, cohesionless soils. Depth to bedrock 400-600 feet.                                                                                                                        | Somewhat more severe shaking than B <sub>s</sub> , affecting tall, flexible buildings.                                                                         |
|                  | D <sub>s</sub> Medium to stiff cohesionless soils. Depth to bedrock 400 feet and, except shallower near Coyote Hills.                                                                                  | Shaking more severe than in A <sub>s</sub> and B <sub>s</sub> , and possibly somewhat more severe than in C <sub>s</sub> , affecting tall, flexible buildings. |
|                  | E <sub>s</sub> Soft to medium cohesionless soils in upper 50 feet. Depth to bedrock 400 feet or greater.                                                                                               | Severe shaking on some sites, affecting tall, flexible structures.                                                                                             |
| LIQUEFACTION     | F <sub>L</sub> Santa Clara and other rock formations.                                                                                                                                                  | Negligible.                                                                                                                                                    |
|                  | G <sub>L</sub> Stiff clays and dense sands (alluvium or residuum above rock). Groundwater at 20 feet or deeper. Some perched water.                                                                    | Low liquefaction potential, except where saturated sands are found in steep topography.                                                                        |
|                  | H <sub>L</sub> Variable mixture of clays and loose to medium silts and sands, in upper 20 feet. Deeper soils on sand-gravel mix. Groundwater varies from 5 to 40 feet below surface.                   | High to low liquefaction potential depending on depth to groundwater, soil conditions and topography.                                                          |
|                  | J <sub>L</sub> Clay, silts, sands in upper 15-20 feet, gravel and sand below. Marshy areas near Hayward fault. Groundwater 30-60 feet below surface.                                                   | Liquefaction potential low except in marshy areas near Hayward fault.                                                                                          |
|                  | K <sub>L</sub> Clay, silt, sands in upper 50 feet, sand and gravel below. Groundwater 30-60 feet below surface; perched water at 5 feet below surface.                                                 | Low to high liquefaction potential depending on depth to groundwater. Minor to moderate differential settlements could occur.                                  |
|                  | L <sub>L</sub> Stiff clays. Shallow groundwater (5-20 feet); considerable perched water.                                                                                                               | Low liquefaction potential.                                                                                                                                    |
|                  | M <sub>L</sub> Stiff clays with silt and sand lenses. Shallow groundwater (5-20 feet).                                                                                                                 | Moderate to high liquefaction potential.                                                                                                                       |
| SURFACE FAULTING | N <sub>L</sub> Recent Bay Mud, overlying older alluvium and older mud. Groundwater at 3-10 feet below surface.                                                                                         | High liquefaction potential.                                                                                                                                   |
|                  | I Fault is characterized by narrow zone of surface faulting.                                                                                                                                           | Ground rupture and distortion during an earthquake; creep.                                                                                                     |
|                  | II Zone of complex faulting; locations of active traces is imprecisely known and additional traces may exist.                                                                                          | Ground rupture and distortion during an earthquake; creep.                                                                                                     |
|                  | III Zone of faulting mapped, but trace has not been located. Data to support existence of fault are not conclusive.                                                                                    | Possible rupture and distortion during an earthquake. Appears to be a much lower hazard than Hayward fault.                                                    |
| SLOPE STABILITY  | X Briones formation: 0-14% slopes Orinda formation: 0-14% slopes Santa Clara formation: 0-14% slopes Other bedrock: 0-29% slopes                                                                       | Possible localized landslides.                                                                                                                                 |
|                  | Y Briones formation: 15-29% slopes Orinda formation: 15-29% slopes Santa Clara formation: +30% slopes Other bedrock: +30% slopes<br>Note: Santa Clara formation is more stable at +30% than at 15-29%. | Possible major landslides in localized areas.                                                                                                                  |
|                  | Z Briones formation: +30% slopes Orinda formation: +30% slopes Santa Clara formation: 25-29% slopes                                                                                                    | Possible localized landslides within a widespread area.                                                                                                        |



Area I is the portion of the Hayward fault zone in which the active fault trace is well-defined by surface features and well-documented by subsurface geologic investigations. Surface faulting is confined to a narrow zone.

Area II is the portion of the Hayward fault zone where the fault has been found to branch out into numerous subsidiary fault traces.

Area III includes the Mission fault zone. This zone has been included in the Geologic Hazard Special Studies zones established by the State of California and therefore studies to determine the location of the fault trace are required for development proposed in the mapped zone, as they are in the Hayward fault zone. Substantial doubt as to the existence of this fault has been expressed by geologists who have attempted to locate an active trace in the designated area.

#### **b. Ground-shaking**

Ground-shaking or earthquake shaking is produced by displacement along a fault. The shaking is both damaging in itself and because of the secondary hazards it triggers. The intensity of shaking for all structures will depend on the size and distance of the earthquake. For low buildings and structures, such as wood-frame houses, the severity of shaking will not be significantly affected by local site conditions, such as the types of subsurface materials. For tall buildings, such as steel-frame multi-story structures, local site conditions may have a considerable effect on the severity of shaking, since these buildings tend to pick up the frequency of the ground motion. In general, shaking is least severe on rock foundations. The great San Francisco earthquake of 1906 produced less damage to structures on the hills, while buildings were extensively damaged in the valleys and filled areas along the bay. In Fremont, the intensity of shaking can be expected to be greater in areas underlain by recent alluvium and Bay mud. These areas are shown on the Geologic Hazards Map (Map 1). Areas designated A are the bedrock areas, areas designated E are the areas where the intensity of shaking is expected to be the greatest.

#### **c. Liquefaction**

Liquefaction refers to the process in which a saturated cohesionless soil, such as sand or silt, may be transformed into a liquid as a result of earthquake vibration. Liquefaction is thus one of the secondary affects triggered by ground shaking. When soil liquefies, it loses its bearing strength and may densify, causing settlement, or may flow toward a free face such as a depression, excavation or creek. In the latter case, buildings and structures above the liquefied layers could be tilted or damaged by the loss of a portion of their soil foundation. The potential for damage from liquefaction depends on the depth of the liquefied zone, local topographic conditions, and the nature of the construction.

In the Fremont area, the potential for liquefaction during earthquake shaking is related to the presence of ground water and of pockets or lenses of fine-grained materials, such as sand or silt. The alluvial plain on which much



of Fremont is situated is crossed by numerous abandoned stream channels which form such pockets. This creates a potential for localized liquefaction in much of the city. Sand layers within the bay mud are also prone to liquefy; generalized liquefaction may occur in the Baylands during an earthquake.

The areas of relative liquefaction potential are described on the Geologic Hazards Map (Map 1) and an explanation of the zones delineated on the map is included in Table I. The liquefaction potential is least in Area F, and greatest in Area N; however, the intermediate categories, such as G, H, and J, do not represent ascending degree of hazard as much as differing types of soil and groundwater conditions which have a similar potential for localized hazards.

#### **d. Slope Stability**

Landslides and the potential for landsliding are found in the Fremont hills. These conditions provide one of the major reasons for designating the steeper and less stable slopes as Open Space in the General Plan. Although landslides may occur at any time, particularly during the rainy season, earthquake shaking frequently triggers rapid slides on unstable, sloping land. This factor could greatly increase the magnitude of earthquake-related damage, injury and loss of life, disruption of utilities, and blockage of public and private access in or at the base of the hills. An earthquake occurring in the late winter, when the soils are highly saturated, would be the most hazardous in terms of landslide danger.<sup>18</sup> Maps of landslides based on photointerpretation of anomalous contour lines and disturbed soils show an extensive area of landslides along I-680 south of Curtner Road and on the westerly slopes of Mission Peak, Mt. Allison, and Monument Peak.<sup>19</sup> New slides could develop in hillside areas, particularly whenever the natural slope has been steepened or the toe of the slope has been cut away for road construction or a building pad.

#### **e. Tsunamis and Seiches**

Tsunamis or "tidal waves," and seiches, are waves generated in bodies of water by earthquake shaking. These phenomena may also be produced by underwater earth slides, subsidence or uplifting, or slides into reservoirs, lakes and bays. Tsunamis generated by Pacific rim earthquakes, such as the 1964 Prince William Sound, Alaska, quake have not produced damaging waves on the shoreline of the South Bay despite runups of 7 to 10 feet at the Golden Gate. A map produced by the USGS showing areas of potential tsunami inundation in the San Francisco Bay Region states in the accompanying text that areas most likely to be inundated are marshlands, tidal flats, and former bay margin lands that are not artificially filled but still at or below sea level.<sup>20</sup> The impact of tsunamis has also been considered in the Open Space Element of the General Plan.

The map indicates that in the event of a tsunami with a 20-foot runup at the Golden Gate, inundation would occur on the causeway sections of the Dumbarton Bridge, over the salt evaporators westerly of Coyote Hills and



along the margins of Newark and Mowry Sloughs and Coyote Creek. Inundation in the area of Newark Slough would affect the Hetch-Hetchy Aqueduct and Southern Pacific track crossing the Bay from Dumbarton Point to East Palo Alto. The main danger to human lives would be to persons crossing the Dumbarton Bridge: the planned replacement of the present bridge with one designed to elevate traffic above the probable height of a tsunami will eliminate this problem.

Damaging seiches, or oscillating waves, in lakes, bays or reservoirs<sup>21</sup> would not be produced by the small, shallow lakes and ponds in the Fremont area. The danger to Fremont from seiches would be from the overtopping or failure of dams at the large reservoirs in the Sunol area, which may produce destructive flooding through Niles Canyon.

## **f. Flooding**

### **(1) General Hazards**

Flood hazards in the Fremont area have been largely eliminated through projects of the Alameda County Flood Control and Water Conservation District and the U.S. Army Corps of Engineers. The Flood Control facilities, which include various types of channel improvements for the smaller creeks and drainageways, are designed to handle flooding up to and including the 50-year flood (i.e., a flood that can be expected to occur once in 50 years). The Alameda Creek Federal Project is designed to carry a 250-year flood.<sup>22</sup>

Flooding in excess of the 50-year flood will cause some inundation of low-lying areas. The maps of the 100-year flood inundation areas, developed for the U.S. Department of Housing and Urban Development's Flood Insurance Program, were released by HUD in March, 1975. Map 3 shows the areas which are expected to be affected by a 100-year flood.

### **(2) Flooding Related to Earthquakes**

Flooding could accompany an earthquake under the following conditions:

- . A dam or storage tank fails, releasing a large quantity of water.
- . The earthquake establishes a wave motion (seiche) in a reservoir causing the dam to fail or allowing water to overtop the dam and flood the area below the dam.
- . A stream is dammed by a landslide, creating a temporary impoundment. When the action of the impounded water breaches the temporary dam created by the slide, flooding will occur if the volume of water exceeds the capacity of the stream channel.
- . Earthquake-triggered landslides into reservoirs. In the San Fernando earthquake of February, 1971, the upstream face of an earthen dam slid into its reservoir, creating water displacement that nearly overtopped the remaining dam structure.<sup>23</sup>



The impact of earthquake-generated flooding on inhabited areas below dams has been stressed in the report *A Study of Earthquake Losses in the San Francisco Bay Area*.<sup>24</sup> This report projected that failure of the Calaveras, Del Valle, or James Turner dams would release a large volume of water into Niles Canyon, exposing the population of Fremont, Newark and Union City to a major hazard and destroying property and essential public facilities. The report noted that the risk of injury and death would be increased at night, when a larger number of residents would be at home. Map 2 shows the daytime and nighttime population of Fremont by traffic zones. This information is useful for developing an evacuation plan for use in the event of major flooding. Flood hazards will be most severe in winter, when streams and reservoirs are full.

Subsequent to publication of the study cited above, the State Division of the Safety of Dams required the strengthening of the Calaveras Dam, based on findings of potential instability in the dam structure. The necessary repairs will be completed in mid-1975. When repaired, the dam should be able to withstand the maximum probable earthquake for the Bay Area, removing all or most of the risk to the Tri-City population.<sup>25</sup> The location of the dams in the Alameda Creek drainage system are shown in Figure 2.

**g. Fire Hazards<sup>26</sup>**

Fire hazards to the community can be grouped in categories: fires in high occupancy buildings, industrial fires, fires in major communication centers, fires spreading through densely developed areas, and hillside and range fires. The first three of these stand a reasonable chance of occurring as a result of a major earthquake. In such instances, water line breakage, due to shaking, ground failure or fault rupture, will seriously hamper fire-fighting. The greatest concern is with multiple-story, high-occupancy structures. Such buildings are usually dependent on elevators for movement of persons. If the elevators have not been rendered inoperable by an earthquake, they will be taken out of service by the Fire Department for safety reasons. This means that the stair towers will need to be used both by persons evacuating the building and firemen entering the building with fire-fighting equipment. If an earthquake has occurred, experience in other areas has shown that the stair towers may be partially blocked by debris. The existing multi-story, high-occupancy buildings of concern to the Fremont Fire Department are Washington Hospital, the Federal Aviation Administration Air Traffic Control Center, the City Government Building, the Dominican Convent and Holy Family Novitiate, and the Parkway Towers apartment building. The hospital, convent and novitiate present the added problem of evacuating non-ambulatory persons.

Serious problems of fire equipment access in the event of fire or earthquake accompanied by fire are expected at Ohlone College, unless emergency access is improved.

Industrial fires and chemical spillage requiring Fire Department action are a second category of fire hazard with community-wide impact. Facilities which represent the greatest hazard include the bulk petroleum plants on Niles





# FREMONT GENERAL PLAN SEISMIC SAFETY AND SAFETY ELEMENTS

DAYTIME - NIGHTTIME  
POPULATION  
BY  
TRAFFIC ZONES  
1974

## LEGEND

(249) NIGHTTIME

(862) DAYTIME

AREAS OF HIGHEST NIGHTTIME POPULATION CONCENTRATION

LOCATIONS WITH DAYTIME POPULATIONS OF 500 OR MORE  
(INCLUDES SCHOOLS, EMPLOYMENT CENTERS, MAJOR SHOPPING  
CENTERS & DISTRICTS)

FREMONT CITY BOUNDARY



## MAP 2

THIS MAP IS ONE OF SEVERAL WHICH ACCOMPANY THE  
TEXTUAL MATERIALS OF THE SEISMIC SAFETY AND  
SAFETY ELEMENTS IN THE FREMONT GENERAL PLAN. IT  
IS INTENDED TO ILLUSTRATE THE CONCEPTS AND PROPOSAL  
OF THE ELEMENT AND SHOULD BE USED FOR GENERAL  
PLANNING PURPOSES ONLY. PRECISE PLAN DATA MUST BE  
USED TO SUPPLEMENT THIS INFORMATION AT THE TIME OF  
PLAN IMPLEMENTATION.

MARCH 1975









FIGURE 2

RESERVOIRS AND DAMS  
ON ALAMEDA CREEK AND ITS TRIBUTARIES



Boulevard in Niles and on Baine Avenue in Centerville, the AmChem plant at the southerly end of Niles Boulevard, the Ethyl Corporation Visqueen plant on Blacow Road, the Kroehler Manufacturing Company on Central Avenue, and the Borden Chemical Company on Boyce Road. Several of these plants produce or store chemicals which are extremely toxic when burned. Fires, explosions or spillages at these facilities could block streets, damage adjacent properties and require evacuation of the surrounding population. Additional problems of community exposure to flammable or otherwise dangerous materials are created by rail and highway transport of chemicals, including cryogenics, corrosives and radioactive materials.

Conflagrations involving numerous structures are possible in densely developed residential areas, particularly some of the wood-frame apartment complexes with densities of approximately 30 units per acre. In the event of an earthquake, gas main breaks or electrical shorts would be the source of many such fires. Such fires will be difficult to control because of restricted access.

Fires in natural areas and rangelands do not presently pose a major threat to lives or property. If development occurs in the hills and canyons, this hazard will increase.

#### **D. GEO-SEISMIC HAZARDS TO STRUCTURES AND UTILITIES**

##### **1. Effects of Earthquake Activity on Buildings<sup>27</sup>**

###### **a. Wood Frame Construction**

This type of construction is unlikely to collapse from earthquake shaking, although chimneys, porches and stucco may be damaged in even moderate quakes. The light weight, extensive bracing, and low elevation of wood frame buildings account for their resistance to collapse. Damage and hazards to occupants and contents may occur from falling chimneys, breaking glass, falling furniture, cracked and fallen plaster or facing materials, and broken utility connections. Split-level houses with bedrooms over a garage are more prone to collapse than one-story or full two-story houses. This is due to uncompensated weakness of the open garage area, which lacks the bracing effect of four solid walls and of the partitions found in the remainder of the house.

Older wood-frame structures weakened by rot or termite infestation may break away from their footings, generally rupturing all utility connections. Damage to electric and gas connections and to chimneys can result in fires, which will be difficult to fight if water is unavailable or under low pressure due to breaks elsewhere in the distribution system.

Under conditions of ground subsidence or ground rupture, wood-frame construction may be severely damaged. In virtually all cases, however, wood-frame buildings will probably provide safe shelter until the occupants can leave the building safely.



**b. Masonry and Reinforced Concrete Construction**

Unreinforced brick, stone or block buildings are the most failure-prone structures found in urban areas. Fortunately, Fremont has very little construction of this type. Reinforced concrete construction can be designed to be highly earthquake resistant. However, numerous reinforced concrete buildings have failed because the connections between walls, roofs, and floors were not strong enough to withstand shaking. Small industrial buildings with tilt-up walls suffered numerous failures in the 1971 San Fernando earthquake, because the connections between the plywood roofs and the heavy walls were not designed with sufficient strength to resist the experienced shaking. Light steel-frame and glass buildings with reinforced concrete roofs have somewhat similar tendencies to collapse, with the heavy roof creating stresses which the lighter walls may not be adequately designed to withstand.

**c. Steel-Frame Construction**

Steel-frame buildings can be designed to withstand strong shaking and are the preferred type of construction for buildings of fourteen stories and above in seismically active areas. Ductile concrete frame design is considered equivalent to steel-frame design in ability to withstand shaking for buildings up to fourteen stories. Each building, however, will be only as strong under shaking as its weakest connection or component. Tall buildings tend to develop a swaying motion in response to earthquake shaking. The degree of sway depends on the frequency and amplitude of the waves transmitted from the ground to the structure. For earthquake resistance, all structural components of the building must be designed to move as a unit and all connections between components must withstand the forces exerted by the different parts.

**d. Hazards Associated with Non-Structural Elements**

Many of the injuries and deaths sustained in major earthquakes result from the failure of non-structural elements. Falling glass and exterior wall panels are especially hazardous on the streets and sidewalks of high density downtown areas. Signs, parapet walls, spires, and other building appendages are also threats to life and safety. For building occupants, glass, falling light fixtures, false ceilings, and overhead ductwork are hazardous. Home, office, and factory equipment and furnishings are rarely secured to structures and could slide about or overturn, causing damage and injury.

Mechanical systems are also subject to hazards and failures in the event of earthquake shaking or ground subsidence. Boilers, water heaters, standpipes, water storage tanks, air conditioning equipment and other installations are often not firmly secured to the structure. Because these installations usually have a different mass from the main structure, they will tend to move independently unless very thoroughly secured. If any fuel lines are broken by such movement, fire danger is created.



## 2. Hazards to Utility Generating and Distribution Systems

Utility generating facilities, such as electric power stations, water treatment plants and sewage treatment plants, may suffer damage similar to that experienced by industrial plants. Heavy equipment may be overturned or moved off its foundations, severing its connections to other parts of the generating or processing system. Intake and outflow systems may be severed during earthquake shaking due to the different frequencies of motion of the building and the ground. The consequences of such damage are the loss of essential services and the creation of secondary hazards, such as health dangers from spilled sewage, fire damage from escaping fuel or shorted electrical equipment, or flooding and erosion danger from broken water, sewage or treated effluent pipelines. Damage to the electric power generating and distribution system is expected to be so extensive that outages may continue for many days in some parts of the Bay Area following a major quake.<sup>28</sup> Experience with pipelines and transmission lines indicates that these systems are generally flexible enough to withstand groundshaking, except when the shaking is of long duration and results from low frequency, high amplitude waves.<sup>29</sup> This type of shaking is most likely to occur in softer soils, such as alluvium and Bay mud. Landslides and major ground subsidence induced by shaking are generally the direct cause of pipeline breaks.<sup>30</sup> Most systems have been designed to withstand fault displacement; the Hetch-Hetchy system was built with expansion joints where it crosses the Hayward Fault south of Central Park. However, none of the pipeline systems crossing the fault in Fremont and no similar systems elsewhere in California have been subjected to lateral offsets of more than several inches. It is not known whether any of these could withstand an offset of three feet, the amount reported for the 1868 quake.

## 3. Hazards to Communications Systems

Communications systems are highly vulnerable to disruption in the event of a major earthquake or fire. Earthquake shaking and ground subsidence will cause some damage to underground telephone cables. Sensitive equipment in relay stations is likely to be put out of operation. Loss of telephone communications is especially serious because the main emergency communication networks serving Fremont rely on telephone lines. Even temporary failure of the telephone system in the immediate post-earthquake period will interfere with reporting of fires, requests for ambulances, and other attempts by citizens to obtain emergency aid. Likewise, the emergency services themselves depend heavily on telephone communications. Radio systems linking emergency services are rudimentary and incomplete at present.<sup>31</sup>

Radio and television, important means of providing emergency information to the population following a disaster, are also likely to be substantially disrupted for at least 24 hours following a major earthquake. Power supply problems and shaking damage to transmission towers located on Bay mud will be the primary cause of these disruptions.<sup>32</sup>

The FAA Air Traffic Control Center serves all commercial air traffic in the Bay Area. If this building is rendered inoperable, even temporarily, air travel to and from the area would need to be halted. Air disasters could be expected if planes in the air were suddenly unable to receive traffic control information.



#### **4. Hazards to Transportation Systems (See Map 3)**

##### **a. Highways and Bridges**

Principal damage to the highway, freeway and Bay bridge systems resulting from a major earthquake will include earth failure due to landslides or ground subsidence, overpass damage, and damage to bridge approaches. In the San Fernando earthquake, several overpasses and freeway interchange structures collapsed, and others were severely damaged.<sup>33</sup> In poor soils, such as recently deposited alluvium and Bay mud, bridge abutments and supporting piers may move toward the center of the creek or marsh, causing loss of support for the bridge. This phenomenon, lateral spreading, may also cause freeway ramp and overpass sections to pull apart, a major cause of the damage to these structures in the San Fernando quake.<sup>34</sup>

A recent review of the freeway bridges and overcrossings in and around Fremont by the State Department of Transportation showed that two overcrossings on I-680 — the East Warren Avenue undercrossing and the Durham Road overcrossing — would probably be heavily damaged in a major earthquake on the Hayward Fault, if large displacement occurs. These bridges are expected, however, to remain usable.

In the event of an earthquake with large displacement along the Hayward Fault, the future Highway 238/I-680 separation, which crosses I-680 but carries no traffic, is expected to collapse, according to the State Department of Transportation.<sup>35</sup> City staff members noted that this bridge is already partially unseated on its piers. This movement is apparently due to fault creep, since the overcrossing appears to lie directly on the main trace of the Hayward Fault. The Department of Transportation has indicated that it is currently studying this bridge to determine what corrective measures should be taken to eliminate the present hazardous conditions.

The 1933 earthquake centered at Niles caused rockslides that blocked Niles Canyon Road. Landslide blockage of roads will be a serious problem if substantial development occurs in the hills. The greatest landslide danger — whether from earthquake shaking or gravitational forces — is present during the rainy season, when the soil is saturated and more prone to slip.

##### **b. BART**

The BART system was designed with considerable attention to the reduction of seismic hazards. A recent study by the BART engineering staff, however, warns that because much of the BART system crosses structurally poor soils and areas of high water table where ground subsidence may occur, the BART tracks can be expected to be distorted by even a moderate earthquake (MM V or greater). This analysis is based on the damage to railroads in the 1964 Alaska earthquake and in several Japanese earthquakes, in areas where soil conditions were similar to those underlying the BART system. Derailment of BART's high-speed trains could occur from very small amounts of distortion. Debris on the track would also cause derailments and undercarriage

damage. The study recommends that the entire system be shut down whenever a quake large enough to cause track distortion occurs, to avoid derailments that could cost many lives. It is recommended that service not be resumed after an earthquake until the track has been thoroughly checked and any necessary repairs made.<sup>36</sup>

## **5. Water Storage Facilities**

The possibility of the failure of local water storage facilities has been evaluated by the Alameda County Water District, as required by the State Office of Emergency Services. These facilities are shown on Map 3. Inundation maps have been prepared to show areas that would be affected if these reservoirs failed. In all but one case, the water released from these facilities would pond in areas away from homes.<sup>37</sup> These studies do not, however, describe the course of water released by ruptured storage tanks over down-slope areas. These areas are now undeveloped, but care should be taken to avoid construction directly below the storage facilities in the future.

## **6. Flood Control Facilities**

Channels and water courses with earthen banks and levees could collapse in a major earthquake. This might result in partial or complete blockage of channels, which could cause flooding upstream of the impoundment. Lift stations and tide gates could be damaged, eliminating or impairing the control capabilities of the system.<sup>38</sup>





# FREMONT GENERAL PLAN SEISMIC SAFETY AND SAFETY ELEMENTS CRITICAL FACILITIES

## LEGEND

- ACTIVE FAULT TRACES
- \* EXISTING BRIDGE
- \* FUTURE BRIDGE
- EXISTING INTERCHANGE
- FUTURE INTERCHANGE
- ~ ROAD SUBJECT TO LANDSLIDE CLOSURE
- ▨ AREA SUBJECT TO INUNDATION BY A 100 YEAR FLOOD
- ▨ AREA SUBJECT TO TSUNAMI & FLOOD INUNDATION
- ★ CITY HALL
- ▲ FIRE STATION
- ⊙ JUNIOR COLLEGE
- HIGH SCHOOL
- ⬇ JR. HIGH SCHOOL
- ⬆ ELEMENTARY SCHOOL

----- FREMONT CITY BOUNDARY



## MAP 3

THIS MAP IS ONE OF SEVERAL WHICH ACCOMPANY THE TEXTUAL MATERIALS OF THE SEISMIC SAFETY AND SAFETY ELEMENTS IN THE FREMONT GENERAL PLAN. IT IS INTENDED TO ILLUSTRATE THE CONCEPTS AND PROPOSAL OF THE ELEMENT AND SHOULD BE USED FOR GENERAL PLANNING PURPOSES ONLY. PRECISE PLAN DATA MUST BE USED TO SUPPLEMENT THIS INFORMATION AT THE TIME OF PLAN IMPLEMENTATION.

MARCH 1975







### **III. HAZARD AREAS**

#### **A. LOCATION OF EXISTING LAND USE ACTIVITIES IN RELATION TO PHYSICAL HAZARDS**

##### **1. Surface Rupture Hazards**

###### **a. Residential Uses**

Very little residential development is located directly on the active trace of the Hayward Fault, and relatively few residences are found within 50 feet of the mapped trace. This is due to siting requirements followed by the City Building Department since incorporation and also, in part, to the marshy conditions found along the fault trace in several areas.

The Hayward fault underlies a residential subdivision in Niles, crossing diagonally through the area immediately north of the Niles School. The Warm Springs Manor subdivision at Durham Road and I-680 is also traversed by the fault. Several residences located on the northeast side of Mission Boulevard between Niles Canyon and Mill Creek may be on or near the Mission Fault trace; however, the existence of this fault has been questioned because studies conducted for recent developments have not discovered actual fault evidence in this area.

###### **b. Commercial and Industrial Uses**

No commercial activities are located on mapped fault traces. An industrial building located adjacent to the Southern Pacific railroad just north of Washington Boulevard is located on the Hayward fault and has been damaged repeatedly by fault creep. A second industrial building, located on the railroad north of Shinn Historical Park, is also on the Hayward fault. No damage has been reported for this building, which is fairly new and may not have experienced damaging creep.

###### **c. Institutional and Public Uses**

Much of the land traversed by the active Hayward fault trace is in public open space use or is intended for such use in the future. From northwest to southeast, these uses are: the future Niles Quarries Regional Park, Shinn Park, a future trail and open space area bordering the Tule Pond east of the BART station, the BART parking lot and Central Park. The City Government Building site, located between two fault traces, was studied thoroughly to determine the exact fault locations, and the building was specially designed to resist earthquake damage. Future public buildings in the Civic Center will undergo similar study.

###### **d. Transportation Systems**

The Hayward fault is crossed by a number of local and region-serving transportation routes. Many of these crossings are at grade and on level ground; therefore, while the pavement and road bed might be damaged by ground rupture and fault displacement, the street or road could remain passable. Crossings involving elevated structures, trackage or grade separations would be more seriously affected by fault slippage or rupture. Existing facilities which



might have to be closed due to fault activity are the Southern Pacific and Western Pacific railroad tracks at Shinn and near Union Street in Irvington, and the segment of I-680 between Washington Boulevard and Durham Road. If BART is extended to the south, the BART tracks would cross Walnut Avenue directly on the active Hayward fault trace. A grade separated intersection of Washington Boulevard and Driscoll Road would also be very near or even on the Hayward fault, a factor which must be considered in locating and designing such a crossing.

#### **e. Utility Systems**

Map 4 shows the utility and pipeline systems in the Fremont area. With the exception of sewer mains, these systems have valves to control or shut off flows near the points when they cross the Hayward fault.

### **2. Groundshaking Hazards**

No tall buildings, one of the types of structures most prone to damage from groundshaking, are located in the areas where groundshaking is expected to be most severe. Older masonry buildings in Irvington could be badly damaged by groundshaking. Tilt-up industrial buildings in the Irvington and industrial areas could be damaged if the connections joining the walls and roofs are weak.

### **3. Landsliding and Ground Subsidence Hazards**

Existing development in the hill areas consists of scattered rural residences and ranch buildings and utility transmission systems and pipelines. The utility and pipeline systems have been constructed through areas of low to moderate landslide potential; areas of high landslide potential have been avoided. Similarly, very few dwellings, farm buildings, and access roads are located in the areas shown to have the greatest landslide potential.

The areas of moderate to high liquefaction potential are those most likely to experience ground subsidence during a major earthquake. The Baylands and adjacent areas underlain by Bay mud are most subject to liquefaction. Utilities, communication, and transportation facilities are the principal installations in these areas. Included are the KGO radio substation west of the Coyote Hills, the Dumbarton bridge and its approaches, several P.G.&E. electric transmission lines and a large P.G.&E. substation, a Shell Oil Company petroleum products line, and the Hetch-Hetchy aqueduct. The three sewage treatment plants operated by the Union Sanitary District are located in areas of moderate to high liquefaction potential, as are the mains that serve the plants.

### **4. Flood and Tsunami Hazards (See Map 3)**

Inundation from a 100-year flood is projected in the following areas:

- . the narrow Alameda Creek flood plain in Niles Canyon;
- . the area surrounding Lake Elizabeth, extending into the Mission Valley subdivision;
- . Olive Avenue and vicinity east of I-680;

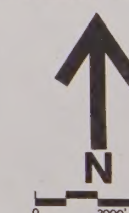


# FREMONT GENERAL PLAN SEISMIC SAFETY AND SAFETY ELEMENTS UTILITY & PIPELINE SYSTEMS

## LEGEND

- HETCH HETCHY / SOUTH BAY AQUEDUCTS
- PACIFIC GAS & ELECTRIC POWER LINES
- PACIFIC GAS & ELECTRIC GAS LINES
- WATER MAINS 16" OR LARGER  
(EXCEPTIONS ON MISSION & NILES BLVD.)
- RESERVOIR
- ◆ WATER STORAGE OR WELLS
- UNION SANITARY DISTRICT SEWER MAINS
- PACIFIC TELEPHONE & TELEGRAPH
- SOUTHERN PACIFIC CO. PIPELINE  
SHELL OIL PIPELINE
- ▨ P.G. & E. SUBSTATION
- ▩ SEWAGE TREATMENT PLANT
- ACTIVE FAULT TRACES

— FREMONT CITY BOUNDARY



## MAP 4

THIS MAP IS ONE OF SEVERAL WHICH ACCOMPANY THE TEXTUAL MATERIALS OF THE SEISMIC SAFETY AND SAFETY ELEMENTS IN THE FREMONT GENERAL PLAN. IT IS INTENDED TO ILLUSTRATE THE CONCEPTS AND PROPOSAL OF THE ELEMENT AND SHALL BE USED FOR GENERAL PLANNING PURPOSES ONLY. PRECISE PLAN DATA MUST BE USED TO SUPPLEMENT THIS INFORMATION AT THE TIME OF PLAN IMPLEMENTATION.

MARCH 1975







- . Crandall Creek area west of Highway 17;
- . the area immediately east of the Coyote Hills;
- . the southeasterly end of the Skysailing Airport and Fremont Raceway;
- . the Baylands westerly of the Fremont-Newark boundary;
- . the KGO transmitter.

Tsunami hazards would be limited to the Dumbarton bridge, KGO transmitter and the immediate shoreline area. The shoreline area that is subject to tsunami action is almost entirely within the proposed South Bay National Wildlife Refuge.

## **B. ANALYSIS OF THE GENERAL PLAN IN RELATION TO THE FINDINGS OF THE SEISMIC SAFETY AND SAFETY ELEMENTS**

### **1. Surface Rupture Hazards**

The Hayward fault runs the length of Fremont. The fault traverses areas designated on the General Plan for low and medium density residential development in Niles, the Central area, Irvington and Warm Springs. Public Open Space and transportation facilities occupying much of the land traversed by the Hayward fault in the Central area, Irvington and Mission San Jose. An area of industrial use south of Alameda Creek in the Central area is also traversed by the Hayward fault. The Mission fault crosses through areas in the Niles, Mission San Jose and Warm Springs foot hills designated for low density residential use and private open space. Institutional uses, such as the college and the mission-related uses in Mission San Jose, are also in an area traversed by the Mission fault.

Most current engineering and geological opinion holds that development can be placed near an active fault trace with no increase in risk from earthquake damage if soil foundation conditions are suitable. Structures should not be placed across fault traces and areas in close proximity to fault traces should be thoroughly investigated for branch faults before development is approved. The State of California has designated the area extending one-eight miles from active fault traces as a Special Studies zone, requiring fault location studies for development proposed within any such zone. It therefore appears unnecessary to establish a mandatory setback from the fault traces or to designate an open space corridor along the traces for this purpose.

### **2. Groundshaking Hazards**

Much of Fremont will experience strong shaking in the event of a major earthquake. The areas expected to undergo the most severe shaking are near the Coyote Hills in the Northern Plain and portions of the Baylands. This analysis is based on the alluvial soils and relatively high water table found in these areas. Groundshaking will be least severe in the hill and upland areas.

Only one small area subject to severe ground shaking has been designated on the General Plan for development. This is a portion of the area designated for industrial use just east of the Dumbarton Bridge toll plaza. The other areas of severe groundshaking potential, near the mouth of the Coyote River, are designated for permanent open space use as salt evaporators or are included in the South San Francisco Bay National Wildlife Refuge.



### **3. Landslide Hazards**

The Open Space Element of the General Plan designated areas of steep slope and known landslides as open space. The Open Space zoning district, adopted to implement the Open Space Element, limits development of steep slope areas to very low density and requires compliance with a set of criteria designed to reduce landslide hazards. Development is prohibited on landslides or in the path of landslides.

### **4. Ground Subsidence Hazards**

Extensive ground subsidence in the event of strong earthquakes shaking is predicted for areas underlain by Bay mud. Localized ground failure may occur in other areas during a major earthquake. The areas subject to general ground failure presently have General Plan designations of industrial use, public open space use, medium density residential use, and transportation facilities, including portions of the Fremont Airport. These areas are located in the westernmost portion of the Northern Plain, in the Baylands and in the industrial area. The most westerly of these lands are classified by the U.S. Soil Conservation Service as Land Capability Class VIII. Such lands will be designated Open Space when the Baylands Area plan is amended to implement the Open Space Element of the General Plan (this amendment is scheduled for presentation to the Planning Commission in September, 1975.) The remainder of the soils in this area have a Land Capability Classification of III and would not be designated Open Space. Development need not be totally prohibited in either of these areas. However, thorough testing of the liquefaction potential of any proposed development site should be required. In general, these areas will be more appropriate for light, low structures and for low intensity uses than for tall structures and intensive uses. These land use factors should be considered in the revision of the Northern Plain Area Plan.

### **5. Flood and Tsunami Hazards**

Most of the areas subject to flood inundation are located in the western portions of the City and have been designated primarily for permanent open space use as salt evaporators and salt marsh, and as parks. Flooding from a 100-year or greater flood would affect the area of the Northern Plain extending roughly one half mile easterly of the Coyote Hills. The southerly half of the area designated for airport use and the adjacent industrial lands would also be inundated, with flooding expected to extend as far east as the Nimitz Freeway and affect the Nimitz-Fremont Boulevard interchange. Industrial land use designations south of Warren Avenue and west of the Nimitz would also be inundated in a 100-year or greater flood.

To the east, a 100-year flood would produce flooding of area around Lake Elizabeth, designated for institutional, open space, residential and transportation activities. Future development in this area will be sited and designed to avoid flood hazards as has been done with existing development. Similar siting and design precautions have been used in a small residential designated flood-hazard area north of Washington Boulevard in Mission San Jose. Tsunami hazard affects only Bay margin lands designated for permanent open space uses.



#### IV. REDUCTION OF HAZARDS THROUGH GOVERNMENTAL ACTIONS

##### A. EXISTING GOVERNMENTAL PROGRAMS FOR EARTHQUAKE HAZARD REDUCTION

###### 1. State Programs and Requirements

The State of California requires local government to carry out certain State-mandated programs to reduce earthquake risks. The Field Act, requiring schools to meet earthquake resistive construction standards, and the Alquist-Priolo Geologic Hazards Zones Act are the most important of these programs. In addition, the State conducts several significant research and regulatory programs to reduce earthquake risks.

###### a. Regulation of Public Schools under the Field Act

Following the 1933 Long Beach earthquake, in which several public schools were totally destroyed, the State Legislature adopted the Field Act. The act, administered by the State Office of Architecture and Construction, requires new public schools to be built to earthquake resistive standards and applies retroactively to public schools in existence before the Act was passed. In 1967, additional legislation was passed requiring geologic investigations of proposed school sites and prohibiting construction in seismically or geologically unsafe areas.

Existing public schools which do not meet the Field Act standards must be brought into conformance with these standards by June 30, 1975. Fremont's Washington High School, the only non-conforming school in the Fremont Unified School District, is currently being brought up to standard.<sup>39</sup>

Private schools are not covered by the Field Act, but new structures are subject to review and approval by the City Building Official. As a result, these facilities are subject to both the structural standards of the Uniform Building Code and the siting standards of the Geologic Hazards Zones Act (see below).

###### b. Geologic Hazard Zones Act (Public Resources Code, Chapter 7.5(2))

Legislation requiring the preparation of geologic reports for all development proposed in proximity to earthquake fault traces was adopted by the State in December, 1972. Pursuant to this act, the State Division of Mines and Geology has prepared Special Studies Zone maps, delineating areas where such reports are required. The Special Studies Zones extend one-eighth of a mile (685 feet) from each side of known active fault traces. Local governments are responsible for receiving and reviewing the geologic reports, and for requiring that any findings and recommendations from the reports are properly used in the development. Copies of the reports are submitted to the State.

The Geologic Hazard Zones Act does not preclude development in the areas defined as Special Studies Zones, but seeks through adequate study to insure that development does not take place on unmapped or inaccurately mapped fault traces or splinter faults. The hazard zones specified in the act include the areas where most of the splinter or branch faulting has been shown to



occur. Development is precluded, however, within 50 feet of the mapped fault trace, unless extremely thorough investigation shows that no hazard exists. Within this 50 foot zone, movement on the fault may cause ground distortion, which would be highly damaging to structures.

The present law is somewhat unclear in its application to additions or alterations made to existing buildings and to land development projects. Clarification and modification of some of these provisions are anticipated.

**c. Division of Safety of Dams**

This division of the Resources Agency has undertaken a study of the safety of all dams above a minimum size. The study has included 203 dams in the Bay Area. As a result of this study, earth fill dams, such as the Calaveras dam on Alameda Creek, have been required by the Division to be made earthquake resistant. Dam failure constitutes one of the greatest threats to life and property of all natural disasters because of the large populations that typically are exposed to danger.<sup>40</sup>

**d. Strong Motion Instrumentation Program<sup>41</sup>**

Strong motion instruments to measure the amount of acceleration experienced by buildings during earthquakes are being installed in selected buildings statewide by the California Division of Mines and Geology. The program provides an important technique for relating ground motion to building motion for a better understanding of the effects of earthquakes on different types of structures. The program is financed by a fee attached to building permits. Fremont adopted its own strong motion instrumentation program prior to passage of the legislation implementing this program and is therefore exempt from the fee requirement. Under both the Fremont and the State programs, strong motion accelerographs are installed in buildings over six stories. One instrument is installed in the basement, one at a point mid-way up the structure and one at the top.

**e. San Francisco Bay Conservation and Development Commission**

The San Francisco Bay Conservation and Development Commission (BCDC) was created by the Legislature in 1965. One of the concerns of BCDC is the safety of construction on baylands and bay fill areas. In Fremont, such construction is, and will continue to be, limited primarily to utility systems. Careful BCDC review of these and any other projects for seismic design and other types of hazard reduction measures is important to the maintenance of these essential facilities.

**f. Geologic Hazards Advisory Committee and Joint Committee on Seismic Safety**

These two bodies, made up of scientists and engineers, have made extensive recommendations for additional State programs and have provided considerable information and recommendations for local government use in establishing earthquake safety programs.



## **2. City Programs**

The City of Fremont has applied its Building Code and Grading Ordinance to reduce geo-seismic hazards and has required fault location studies for certain types of development since the City's incorporation in 1956. In 1972, the City adopted the Open Space Element of the General Plan, and Zoning Ordinance requirements for areas designated Open Space. One of the purposes of the Open Space district is to protect "the public health, safety, and welfare from the dangers of seismic hazards and unstable soils . . ."

### **a. Building Code**

Fremont adopts the Uniform Building Code, prepared and updated triennially by the International Conference of Building Officials. This code is used throughout the western United States. The practice of conducting thorough field investigations of building damage following major earthquakes has led to substantial code revisions in recent years. The 1973 edition of the code includes a new provision requiring the abatement of unsafe building appendages. This provision applies to any existing parapet walls, cornices, spires, towers, tanks, statuary and other appendages which are unable to sustain the design loads specified by the code (Sec. 104(i)). The 1976 edition of the code will include considerable revisions of the lateral force design criteria, based on current research on ground response to earthquakes shaking in varying soil conditions. Earthquake-bracing requirements have been increasing with virtually every code revision since the 1933 Long Beach earthquake.

#### **(1) New Construction**

All new buildings constructed in Fremont must conform to the lateral strength requirements of the Uniform Building Code (UBC), 1973 edition. Throughout California new buildings must be designed to the standards for Zone 3 of the UBC, the zone where greatest earthquake damage to structures can be expected.

#### **(2) Additions, Alterations, and Repairs**

When additions, alterations or repairs made to a building within any 12-month period exceed 50 percent of the building's value, the building as a whole must be upgraded to conform to the code requirements for new construction. If the alterations, additions, or repairs amount to 25 to 50% of the building's value, only the newly constructed portion must meet code standards. When the value of the addition, etc., is less than 25% of the building value, only structural modifications must conform to new-building requirements. These provisions allow the City to require the upgrading of existing buildings whenever major renovations are undertaken.

#### **(3) Unsafe Buildings**

To some degree, code requirements may discourage the improvement of economically marginal buildings. The means of overcoming



such avoidances of needed repairs is enforcement of the Unsafe Buildings section of the Code (Sec. 203). This section permits the City to require abatement of buildings declared to public nuisances, a definition which can include any building deemed hazardous to human life. Abatement consists of repair, rehabilitation, demolition or removal of the nuisance.

The City of Long Beach has enacted an ordinance permitting the Chief Building Official to declare as nuisances any buildings which would be hazardous to human life under earthquake conditions, even though these buildings are otherwise safe. This ordinance is enforced against buildings which can be expected to collapse during an earthquake.

#### **(4) Hazardous Building Appendages**

The 1973 Building Code requires the abatement of hazardous building appendages, such as parapet walls, decorative materials and signs whenever these are unable to meet Code standards for earthquake resistance. Such appendages are much more likely to collapse than are the buildings to which they are attached, and pose serious threats to persons and property below. In Fremont, this hazard is confined principally to the business districts of Niles, Irvington, and Centerville.

Los Angeles and Long Beach have enforced parapet ordinances for a number of years. Initiation of such a program in Fremont would require a limited amount of City inspection. Because the number and extent of appendages is small, such a program is not expected to impose large costs on any property owner required to strengthen or remove a hazardous building appendage.

#### **b. Grading Ordinance**

Fremont's Grading Ordinance applies to all grading undertaken in the City. Permits for grading are required for projects where the natural land slope is 4 percent or greater. The ordinance differs somewhat from the optional grading ordinance included in the Uniform Building Code, requiring more attention to the protection or replacement of vegetation cover, but exempting more activities from the permit requirement. The Fremont ordinance appears to provide adequate controls for the protection of hillside areas provision for adequate drainage for hillside development, and prevention of construction on landslides.

#### **c. Fault Location Studies for New Development**

The general location of the major Hayward fault trace through Fremont has been known for many years. Additional site investigations have refined the mapping of the trace and shown additional parallel traces in several areas. Based on this knowledge, the City has required that all proposals for



development requiring site plan and architectural approval include a geologic report if a fault trace is known or suspected to underlie the property. Planned unit developments, planned districts, apartment developments, and commercial and industrial projects have come under this requirement, since site plan and architectural approval is required for these categories of development proposals. If fault traces are found in the geologic investigation, the site plan is revised to avoid locating any structures astride the trace or traces. This City requirement has been superceded by the recently enacted Geologic Hazards Zone Act. The latter, however, is administered by the City in much the same fashion as the previous City program.

The City is considering adoption of an ordinance specifying the types of projects for which geologic studies will be required and setting standards for such studies. The proposed ordinance would require geologic reports for all essential structures and all proposed buildings four or more stories in height.

Essential structures are defined as emergency service buildings or structures, buildings with occupant loads of 1,000 or more persons, and all buildings used for food processing, food storage, or food sales with a floor area of 10,000 square feet or more.

**d. Open Space Land-Use Designation and Open Space Zoning**

In 1972, the City adopted the Open Space Element of the General Plan and the Open Space district zoning text. One of the goals of the Open Space Element is:

“The establishment of an Open Space system which will provide for the preservation of natural resources, for the managed production of resources, for recreation and for the protection of public health and safety.”

A corollary objective of the Open Space Element is:

“To utilize Open Space as a means of dealing with unstable soil areas such as slide areas, active earthquake fault zones and slopes too steep for urban development.”

In accordance with the implementation program of the Open Space Element, the City has prepared and adopted Open Space amendments to the area plans for Warm Springs, Mission San Jose and Niles. These amendments designate areas of steep slope (30% or greater), known or suspected landslides, and structurally poor soils as Open Space. Low-density development is permitted in these areas, but must conform to a set of performance standards that have been designed to prevent or avoid physical hazards. Fault traces may or may not be included in the Open Space designation, depending on surrounding slope and soil conditions. However, construction in the vicinity of an active fault trace within a Special Study Zone defined is subject to the provisions of the Geologic Hazard Zones Act.



All development proposed in the Open Space district is subject to site plan and architectural approval. This review procedure checks for building placement with respect to streams, for vegetative protection, erosion control and landscaping, and for other factors related to minimizing the danger of landsliding, erosion, and flooding.

## **B. REDUCTION OF SAFETY HAZARDS**

### **1. Possible Areas of Isolation**

No areas of Fremont are likely to be isolated completely by the physical effects of a natural disaster. Partial isolation could occur in Niles and in the Northern Plain, due to bridge and overpass failures, and flooding of the Niles underpasses. Access to Warm Springs would be reduced by bridge failure and landslides on I-680. For planning purposes, the consequence for essential services can be described as follows:

#### **Niles**

Niles is served by a fire station, located on Second Avenue between H and I Streets. Additional fire suppression equipment and personnel that might be required following a disaster could not be obtained from other Fremont fire stations if the Alameda Creek bridges at Mission Boulevard and at Decoto Road were out of service. Such assistance would have to be obtained from Union City or Hayward.

If the bridges are unusable, any person in Niles requiring hospitalization following a disaster would need to be transported to hospitals in Hayward or Castro Valley, unless helicopter transport could be provided to Washington Hospital.

Utility repair crews would be delayed in reaching Niles to repair essential facilities if the bridges were not passable.

#### **Northern Plain**

The portions of the Northern Plain lying west of Highway 17 would be isolated from the remainder of Fremont if the Fremont Boulevard and Decoto Road overpasses should collapse during an earthquake. At present, this area does not have a fire station. Fire suppression assistance would have to be obtained from Newark or Union City, and access from these areas is also dependent on bridges founded on relatively poor soils.

Transportation of sick or injured persons to medical facilities would require either a lengthy trip by auto or helicopter service. Utility repairs would be delayed, although because of limited development in the Northern Plain at this time, the consequences of such delays would probably not be as serious as in the more densely developed Niles community.

#### **Warm Springs**

In the event of a major earthquake, I-680 could be blocked between Washington Boulevard and Warm Springs by overpass failures. This would reduce access to



the Warm Springs area, but would not block emergency services since Mission Boulevard and Warm Springs Boulevard provide alternative routes.

## **2. Existing Services and Facilities for Dealing with Disasters**

### **a. Emergency Response Plan**

The City of Fremont has developed an initial Emergency Response Plan, in compliance with State requirements. The City's plan is intended to be coordinated with State, regional and County emergency plans. By ordinance, the City Manager is the Director of Emergency Services and is responsible for development of the emergency plan. The duty of preparing the basic plan has been delegated to the Chief of Police. All operating departments are required to prepare sub-plans or annexes describing the activities for which they will be responsible in the event of a disaster. The Emergency Response Plan is continually being upgraded by further detailing of these annexes.

The State guidelines for Emergency Response plans have dealt primarily with response to nuclear attack, and the present Fremont plan reflects this emphasis. Currently, however, the State Office of Emergency Services is working with counties, cities, special districts and utilities to broaden the scope of these plans, particularly to make them more applicable to earthquake disasters.

### **b. Obtaining Outside Assistance for Disaster Relief**

#### **County Mutual Aid Program for Fire Suppression**

Alameda County has a coordinated mutual aid program to dispatch fire battalions from each city to fight fires in other cities within the County. Fire departments of adjoining cities respond to fires across city boundaries upon direct request from the other city, notifying the County coordinator of their action. This type of mutual aid will be especially important in the event that Niles or the Northern Plain is isolated from the remainder of Fremont following a disaster. The availability of such assistance is dependent, of course, on whether or not the fire equipment and personnel are needed to suppress fires in their home community.

#### **Helicopter Ambulance Service**

Military helicopters are made available to transport seriously ill or injured persons in disaster areas. The Coast Guard in Alameda and the Army's MAST program at Fort Ord provide such services. Other helicopters owned by the State, County and regional agencies would be made available for critical airlifts in the event of a disaster.

### **c. Emergency Shelters**

The emergency shelters identified in the Emergency Response Plan are limited to those which provide protection against nuclear attack. Those include Washington Hospital, the Dominican Convent, the General Motors Assembly



Plant and the Federal Aviation Agency Air Traffic Control center. The appropriateness of several of these facilities as shelters for other types of emergencies can be questioned. Washington Hospital, for example, will be needed to care for injured persons, the FAA facility can actually accommodate only its own work force, and the Dominican Convent is fully occupied by its residents.

A natural disaster, such as an earthquake or major flood, is unlikely to make the entire population homeless or otherwise in need of shelter. Therefore, shelters sufficient for the entire population are not needed. Shelters should, however, be well-distributed throughout the community, and should be structurally safe. School buildings meet these requirements well, since schools have been required to meet earthquake-resistive design criteria since 1933. The use of schools as shelters is recommended in the *Study of Earthquake Losses in the San Francisco Bay Area*. The City should discuss such a program with the Fremont Unified School District and jointly prepare a set of procedures to be followed in the event of a disaster in which emergency shelters are needed.

#### **d. Water Supply**

The water supply of the Fremont area is provided by the Citizens Utilities Company of California (serving Niles) and the Alameda County Water District (serving the remainder of Fremont).

The Alameda County Water District can deliver 44.2 million gallons of water per day to its service area. The peak demand to date has been 42 million gallons per day (mgd). The total capacity, although currently in excess of the peak day's demand, will be increased to 54.5 mgd when the Mission San Jose treatment plant is placed in operation.<sup>42</sup>

The District maintains a water pressure of 20 pounds per square inch minimum in its system during high fire demand. The District provides water service up to 390 feet elevation. Above this elevation, the district can require developers to provide the pumping equipment and storage facilities necessary to maintain adequate pressure for normal service and for fire suppression.

Citizens Utilities has a delivery capacity of 6 million gallons per day. The peak demand is 3.2 mgd. The average water pressure is 75 psi.<sup>43</sup>

While the two water systems provide adequate fire flow under normal conditions, disruption of water systems would reduce this capability. Such a disruption could occur with even a small amount of offset along the Hayward fault trace. A water main crossing the Hayward fault at Mission Boulevard has broken from fault creep.<sup>44</sup> Loss of adequate water supply for fire suppression is probably the most serious safety hazard affecting Fremont.

#### **e. Evacuation Routes**

Fremont has an evacuation plan geared to nuclear attack, which is being expanded to respond to other types of emergencies. The plan is coordinated with the California Highway Patrol. The need for evacuation routes, and the



appropriate routes, will vary for each type of disaster. The dam failure inundation maps, to be released by the State of Emergency Services, will be the most important source of information for evacuation route selection. For urban fires, major evacuation would generally not be necessary; street closings resulting from fire suppression efforts would be relatively short-lived and would cause inconvenience rather than undue hazards. As noted in the description of isolation areas, road closures may occur at the Niles underpasses, the Alameda Creek bridges, in Niles Canyon, on I-680 in Warm Springs and Mission San Jose and at the Dumbarton bridge.

### **3. Actions to Improve Community Safety**

The major physical impediments to community safety described in the preceding section are disruption of water supply and closing of highways and freeways due to bridge and overcrossing damage. Actions to reduce these hazards are beyond the immediate control of the City: the water distribution system is installed and maintained by the two water utilities; freeway and highway construction and design are under the jurisdiction of the State. The City's role is limited to describing the hazards related to these installations and persuading the responsible bodies to modify their systems and procedures. The City can also compensate for potential isolation problems by decentralizing certain services into areas which may be cut off from the rest of the community following an earthquake or other major disaster.

## **C. CONCEPT OF ACCEPTABLE RISK**

One of the required considerations of the Seismic Safety and Safety Elements is the level of risk that will be acceptable to the community. The Safety Element guidelines issued by the California Council on Intergovernmental Relations defines "acceptable," unacceptable, and "avoidable" risks in the following manner:

- |                    |                                                                                                                                                        |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acceptable risk:   | The level of risk below which no specific action by local government is deemed to be necessary.                                                        |
| Unacceptable risk: | Level of risk above which specific action by government is deemed to be necessary to protect life and property.                                        |
| Avoidable risk:    | Risk not necessary to take because individual or public goals can be achieved at the same or less total "cost" by other means without taking the risk. |

The City has assumed a certain level of acceptable risk in its adoption of a building code, use of street and land development standards, and provision of fire and police services. For certain types of hazards, however, present programs and standards of the City may not provide a comparable level of life safety. Massive failure of an upstream dam or loss of water pressure needed to fight fires following an earthquake are examples of possible hazards which have not been dealt with specifically by existing measures. Adopting standards and programs to reduce the threat of these hazards would not require a change in the level of acceptable risk, but would rather extend that amount



of risk reduction to previously neglected concerns.

The action program of the Seismic Safety and Safety Elements is aimed at achieving an acceptable level of risk for all types of hazards to the community, to the best that impact of these hazards can be predicted from available information.

#### D. EARTHQUAKE INSURANCE

Earthquake insurance can be obtained for residential properties in the Fremont area. The insurance is written as an endorsement to a homeowner or other type of residential policy, and rates are \$1.40-\$2.00 per thousand dollars of insured value. This would result in a \$56-\$80 annual premium for a \$40,000 home. Most earthquake insurance policies carry a 5 percent deductible.

Earthquake insurance is less easily obtained for commercial properties because the insurers do not presently maintain sufficient funds to cover all properties for which insurance might be sought. Rates vary according to the class of construction.



## **V. RECOMMENDED STUDIES AND MITIGATION MEASURES FOR GEO-SEISMIC HAZARDS**

### **A. RECOMMENDED STUDIES (Refer to Map 1)**

#### **1. Ground Shaking**

##### **Ground Response Study**

- . Sampling of soil by means of borings.
- . Development of subsurface profile.
- . Analysis of response of site to ground shaking, based on standard geologic techniques developed for this purpose.

**Required** for flexible structures in Area E<sub>S</sub>; optional in other areas.

#### **2. Liquefaction (See Appendix A for boring depth guidelines)**

##### **Phase I Study**

- . Sampling of soil by means of borings. Guidelines for boring depths are provided in Appendix A.
- . Analysis for cohesionless soils, presence of water.
- . Identification of topographic features which might permit lateral movement or differential settlement.

**Required** for the following uses in Areas G<sub>L</sub>, H<sub>L</sub>, J<sub>L</sub>, K<sub>L</sub>, L<sub>L</sub>, M<sub>L</sub>, N<sub>L</sub>

- . Residential subdivisions (detached and attached units) of 100 or more units.
- . Apartment complexes of 50 or more units.
- . Structures of 4 or more stories or over 35 feet in height.
- . Commercial, industrial and institutional projects with occupancy ratings of 250 or more persons.
- . Essential facilities (hazardous materials, utilities, emergency operations).

##### **Phase II Study**

- . Specific evaluation of liquefaction potential identified in Phase I.
- . Recommendation of specific mitigation measures.

**Required** whenever Phase I study indicates the presence of a potential liquefaction hazard to the proposed land use.



### 3. Surface Rupture

#### Phase I - fault trace location study

Review of existing maps

Surface reconnaissance.

Aerial photointerpretation.

Report and map locating proposed use with respect to mapped fault traces, fault creep, and/or identifying features suggestive of an active fault.

**Required** for all projects for human occupancy located within any Geologic Hazards Special Studies Zone, as mapped by the California Division of Mines and Geology.

#### Phase II - splinter fault location study

Subsurface exploration and documentation to describe location and activity of any splinter or branch faults, based on:

Geophysics

Exploratory borings

Documentation of fault creep

Exploratory trenching

**Required** for projects for human occupancy within 200 feet of any fault trace mapped by CDMG and designated as Area I on the Geologic Hazards Map, and within 300 feet of fault trace mapped by CDMG and designated as Areas II and III as the Geologic Hazards map.

### 4. Slope Stability

**Phase I Study** - Site inspection and report by registered soils engineer or engineering geologist identifying geologic conditions that might present hazards to the proposed land use. Off-site hazards and hazards to access roads and utilities to be included in analysis.

**Required** for all land development and construction proposed in Slope Stability Areas X, Y, and Z, as shown on the Geologic Hazards Map.

**Phase II Study** - Geologic mapping of site from aerial photos and site investigation, to identify unstable formations.

**Required** for all land development and construction proposed in Slope Stability Areas Y and Z.



**TABLE II**  
**B. TABLE OF REQUIRED GEOLOGIC STUDIES**

Key to Studies

L = liquefaction study  
G = ground response study  
S = slope stability study  
F = surface faulting study

Hazard Class as Designated on Geologic Hazards Map

| Project Type                                                                    | A <sub>S</sub> F <sub>L</sub> | A <sub>S</sub> F <sub>L</sub> (x,y,z) | B <sub>S</sub> G <sub>L</sub> | B <sub>S</sub> H <sub>L</sub> | C <sub>S</sub> J <sub>L</sub> | C <sub>S</sub> K <sub>L</sub> | D <sub>S</sub> K <sub>L</sub> | D <sub>S</sub> L <sub>L</sub> | D <sub>S</sub> M <sub>L</sub> | E <sub>S</sub> N <sub>L</sub> | I | II | III |
|---------------------------------------------------------------------------------|-------------------------------|---------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|---|----|-----|
| Large residential subdivisions, 100+ units                                      | —                             | S                                     | L                             | L                             | L                             | L                             | L                             | L                             | L                             | L                             | F | F  | F   |
| Large apartment complexes, 50+ units                                            | —                             | S                                     | L                             | L                             | L                             | L                             | L                             | L                             | L                             | L                             | F | F  | F   |
| Structures of 4 or more stories, or over 35 ft. in height                       | —                             | S                                     | L                             | L                             | L                             | L                             | L                             | L                             | L                             | LG                            | F | F  | F   |
| Institutional, commercial and industrial buildings or complexes, 250+ occupancy | —                             | S                                     | L                             | L                             | L                             | L                             | L                             | L                             | L                             | L                             | F | F  | F   |
| Essential facilities*                                                           | —                             | S                                     | L                             | L                             | L                             | L                             | L                             | L                             | L                             | LG                            | F | F  | F   |
| All other projects                                                              | —                             | S                                     | —                             | —                             | —                             | —                             | —                             | —                             | —                             | —                             | F | F  | F   |

\* Essential facilities are:

(1) Emergency service buildings or structures:

- a. Fire stations, police stations, jails, city government office buildings.
- b. All buildings or structures which are used in connection with the generation, production, distribution, or storage of natural gas, electricity, petroleum products, water, and/or sewage.
- c. All buildings housing emergency communication systems.

(2) All buildings classified as a Group A, B-2 or C occupancy (public assembly or elementary and secondary education facilities) as defined in the building code of the City of Fremont with an occupant load of one thousand or over.



## C. MITIGATION MEASURES FOR GEO-SEISMIC HAZARDS

### 1. Ground Shaking

- a. Lateral force design based on the Uniform Building Code, particularly the 1976 and subsequent editions.
- b. Modified lateral force design requirements as indicated by site response studies.
- c. Siting of projects away from areas of most severe ground shaking, if site response study indicates that mitigating the hazard by means of design will be too costly or will not achieve a satisfactory degree of risk reduction.

### 2. Liquefaction

- a. Avoid construction at sites where specific studies show that liquefaction will occur and that the consequences of liquefaction will be particularly severe. Such areas are those adjacent to major topographic depressions, where major lateral movement could result if liquefaction were to occur. Design of structures to withstand such movements is difficult or impossible.
- b. Design structures to resist the effects of liquefaction (other than major lateral movement)
  - . Use continuous, tied-together foundations for light structures, in order to reduce the effects of settlement or small lateral movement.
  - . Use deep pile foundations to support heavy buildings below the liquefiable layers, or alternatively.
  - . Support heavy buildings on raft or mat foundations which will float and hold the building together despite localized liquefaction, and resist over-turning.
  - . Design the superstructure of a building to resist the effects of settlement through adequate connections and appropriate choice of building materials.
- c. Improve the building site to reduce the possibility of liquefaction or its consequences
  - . Raise the site grade by placing fill
  - . Remove and replace potentially liquefiable soils
  - . Densify potentially liquefiable soils by vibroflotation, use of compaction piles, or lowering and controlling groundwater levels.



### **3. Surface Rupture**

- a. Locate structures at an adequate distance from an active fault trace such that surface faulting is not an unreasonable hazard.
- b. Design structures to accommodate any ground deformation.
- c. Locate low density and low occupancy structures near an active fault, while locating high occupancy and essential structures further away.
- d. Plan for transportation facilities and underground utilities to cross an active trace the fewest number of times.
- e. Design transportation facilities and underground utilities to accommodate fault displacement and equip utilities with shut-off mechanisms.

### **4. Slope Instability**

The natural slope stability can be decreased by grading. Therefore, in all areas, grading should be undertaken with caution and only after the existing geological and soil conditions are known and are considered in the grading plan. In Area Y, grading of the slopes should be minimal but, where essential for development, it should include procedures for improving slope stability. In Area Z, grading of the slopes should be minimal for roadway access and is not recommended for site development. Low density development may be possible if shown feasible by site studies.

Grading of slopes should follow good engineering practices and be in accordance with the grading ordinance.



## APPENDIX A

### SUGGESTED GUIDELINES FOR BORING DEPTHS FOR SOIL LIQUEFACTION STUDIES (See Map 1)

The following guidelines are suggested for borings to investigate the potential for liquefaction:

1. For most areas of the city and most types of construction, a boring depth of 50 feet would generally be adequate for a Phase I study.
2. For very light and flexible construction — that is, wood-frame houses, wood-frame one- to two-story apartment houses, and other similar construction, a boring depth of 40 feet would generally be adequate for a Phase I study.
3. In Area G<sub>L</sub>, which is an area of dense and stiff older alluvium and residual soils, the boring depths given in 1. and 2. for Phase I above generally could be reduced by 10 feet.
4. In addition to 1., 2., and 3. above, it is considered that Phase I borings should extend at least 35 feet below the possible foundation depths (including below the tip elevation of possible pile or pier foundations). In Area G<sub>L</sub>, this depth could be reduced to 30 feet below foundations.
5. In addition to 1. through 4. above, it is considered that for projects constructed in the vicinity of free faces, such as creek channels or gravel pits, borings should extend to depths that are well below the base of the free face.

The guidelines suggested above are not necessarily meant to be applied for every boring drilled during the geotechnical investigation for a proposed project. Rather, it is the intent that selected borings would be drilled to these typical depths to evaluate whether a potential problem may exist. As a general guideline, it is felt that in areas of the city having relatively low liquefaction potential and reasonably uniform subsurface conditions (Areas G<sub>L</sub> and J<sub>L</sub>), relatively fewer borings to these depths would be required to satisfy the Phase I requirements. On the other hand, in areas having either relatively high liquefaction potential or variable subsurface conditions, (Areas H<sub>L</sub>, K<sub>L</sub>, M<sub>L</sub>, and N<sub>L</sub>), it would be appropriate to verify the conditions in a relatively greater number of borings. (Area L<sub>L</sub> is considered to have low liquefaction potential based on the geologic conditions, but data on the detailed subsurface conditions is particularly limited.)



## APPENDIX B

### MODIFIED MERCALLI INTENSITY SCALE OF 1931 (Abridged)

- I. Not felt except by a very few under especially favorable circumstances.
- II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
- III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration can be estimated.
- IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
- V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
- VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
- VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.
- VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.
- IX. Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations; ground cracked conspicuously. Underground pipes broken.
- X. Some well built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
- XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and landslips in soft ground. Rails bent greatly.
- XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into air.



## APPENDIX C

### GLOSSARY OF TERMS

**ALLUVIUM** - A general term for all sediments, such as sand and gravel, transported and deposited by streams.

**EPICENTER** - The point on the earth's surface directly above the point of origin of an earthquake.

**FAULT** - A fracture in the earth's crust along which there has been movement of the two sides relative to each other.

**FAULT TRACE** - A lineation or scar on the earth's surface marking the intersection of a fault with the earth's surface.

**FREE FACE** - An exposed slope, such as a cliff, creek bank or ditch, toward which liquefied soils may flow.

**GENERAL FAILURE** - The subsidence or movement of the ground from landsliding, liquefaction, or undermining.

**GROUND RUPTURE** - A break or fracture of the earth's surface along a fault, also called surface faulting.

**GROUNDWATER** - Water occupying the voids or spaces in soils and rocks. Perched groundwater lies above the normal water table and is prevented from draining to the water table by impervious rocks and soils.

**LIQUEFACTION** - The process of saturated granular soils becoming liquid or "quick" under earthquake shaking. Under such conditions, the soil loses its bearing strength and may settle or flow toward a topographic depression or free face.

**SEICHE** - An earthquake generated wave within an enclosed or restricted body of water, such as a lake, reservoir or lagoon.

**TSUNAMI** - A sea wave generated by underwater ground movement, usually associated with an earthquake.



Footnotes:

- 1 National Oceanic and Atmospheric Administration, Environmental Research Laboratories. *A Study of Earthquake Losses in the Bay Area*. Washington, D. C., U. S. Government Printing Office, 1972, page
- 2 Ibid., pp. 130, 132
- 3 Don L. Anderson "The San Andreas Fault" *Scientific American*, November 1971, pp. 53-68.
- 4 Karl V. Steinbrugge. *Earthquake Hazards in the San Francisco Bay Area*. Berkeley, University of California Institute of Governmental Studies, 1968, pp. 68-71.
- 5 Ibid.
- 6 Woodward-Lundgren & Associates. *Geotechnical Studies, South County Hall of Justice, Fremont, California* prepared for County of Alameda Public Works Department, Oakland, May 15, 1974. pp. 1-4.
- 7 Steinbrugge, op. cit.
- 8 *The History of Washington Township*
- 9 California State Earthquake Investigation Commission. *The California Earthquake of 1906*. Washington, D. C.: Carnegie Institution of Washington, 1908-10. Andrew C. Lawson, Chairman.
- 10 Woodward-Lundgren & Associates. *South County Hall of Justice study*, op. cit., pp. 1-4.
- 11 Steinbrugge, op. cit. p. 10.
- 12 Lloyd Cluff, lecture: "Seismic Hazards in Urban Areas" conference on Planning for Seismic and Environmental Hazards in Urban Areas, University of California, Berkeley, February 21-23, 1974.
- 13 National Oceanic & Atmospheric Administration, op. cit., p.
- 14 Woodward-Clyde and Associates. *Fremont Meadows Active Fault Investigation and Evaluation*. Oakland, June 1970, pp. 22-23.
- 15 Steinbrugge, op. cit., p. 10
- 16 Dorothy H. Radbruch. *Map Showing Recently Active Breaks Along the Hayward Fault Zone and the Southern Part of the Calaveras Fault Zone, California*. U.S. Geological Survey Open File Map, 1968.
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- 18 Tor H. Nilsen and Earl E. Brabb. U. S. Geological Survey. *Preliminary Photointerpretation and Damage Maps of Landslide and Other Surficial Deposits in Northeastern San Jose, Santa Clara County, California*. Basic Data Contribution 45, 1972.
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- 20 J. R. Retter and W. R. Dupre. USGS. Map Showing Areas of Potential Inundation by Tsunamis in the San Francisco Bay Region, California. Basic Data Contribution 52, 1972
- 21 D. R. Nichols and J. M. Buchanan-Banks. *Seismic Hazards and Land-Use Planning*. Geological Survey Circular 690. U. S. Geologic Survey, Washington, D. C., 1974, p. 24.
- 22 Paul Lanferman, Engineer-Manager, Alameda County Flood Control and Water Conservation District, personal communication, August 26, 1974, and February 6, 1975.
- 23 National Oceanic and Atmospheric Administration, op. cit., 1972
- 24 National Oceanic and Atmospheric Administration, op. cit., 1972.
- 25 John Halsted, California Division of Safety of Dams, Personal Communication, February 13, 1975.
- 26 Captain J. E. Burge, Fremont Fire Department, personal communication, February 5, 1975.
- 27 The information in this section is based on lectures by four structural engineers and architects specializing in earthquake design. The four are:

H. J. Degenbolb, structural engineer. H. J. Degenbolb and Associates, Engineers, San Francisco

Henry Lagorio, Professor of Architecture, University of California, Berkeley

Karl V. Steinbrugge, Professor of Structural Design, University of California, Berkeley, and Structural Engineer, Pacific Fire Rating Bureau, San Francisco

Peter Yanev, Associate Professor of Structural Engineering, University of California, Berkeley
- 28 Steinbrugge, "Seismic Hazards in Urban Areas"; also D. F. Moran, "Damage to Energy and Communications Systems," in the San Fernando, California, Earthquake of February 9, 1971 (pp. 245-247); also National and Oceanographic and Atmospheric Administration, op. cit. (pp. 181-182).
- 29 Pacific Gas and Electric Company, "Summary Paper on Seismic and Safety Elements," June 15, 1974; also Steinbrugge, op. cit. and D. F. Moran, op. cit.
- 30 Reuben Kachadoorian, United States Geological Survey, *Correlation Between Pipeline Damage and the Geologic Environment during an Earthquake*, unpublished paper, 1974.
- 31 National Oceanic and Atmospheric Administration, op. cit. (p. 151); also Capt. John Crowder, Fremont Police Department, and Capt. J. E. Burge, Fremont Fire Department, personal communications.



- 32 National Oceanic and Atmospheric Administration, op. cit. (p. 150).
- 33 National Oceanic and Atmospheric Administration, op. cit. (p. 150).
- 34 Kachadoorian, op. cit.; Seed, op. cit.
- 35 Personal communication, B. C. Bachtold, Deputy District Director, Department of Transportation (District 4), Department of Community Development, January 27, 1975.
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- 38 Personal communication, Paul E. Lanferman, Engineer-Manager, Alameda County Flood Control and Water Conservation District, August 26, 1974.
- 39 Facilities Division Fremont Unified School District personal communication, November, 1974.
- 40 Steinbrugge. *Earthquake Hazard in the San Francisco Bay Area*. op. cit., p. 54.
- 41 Section 2708, Public Resources Code
- 42 Alameda County Water District, personal communication.
- 43 James O'Keefe; Citizens Utilities Company, personal communication.
- 44 City of Fremont Engineering Division, personal communication.







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